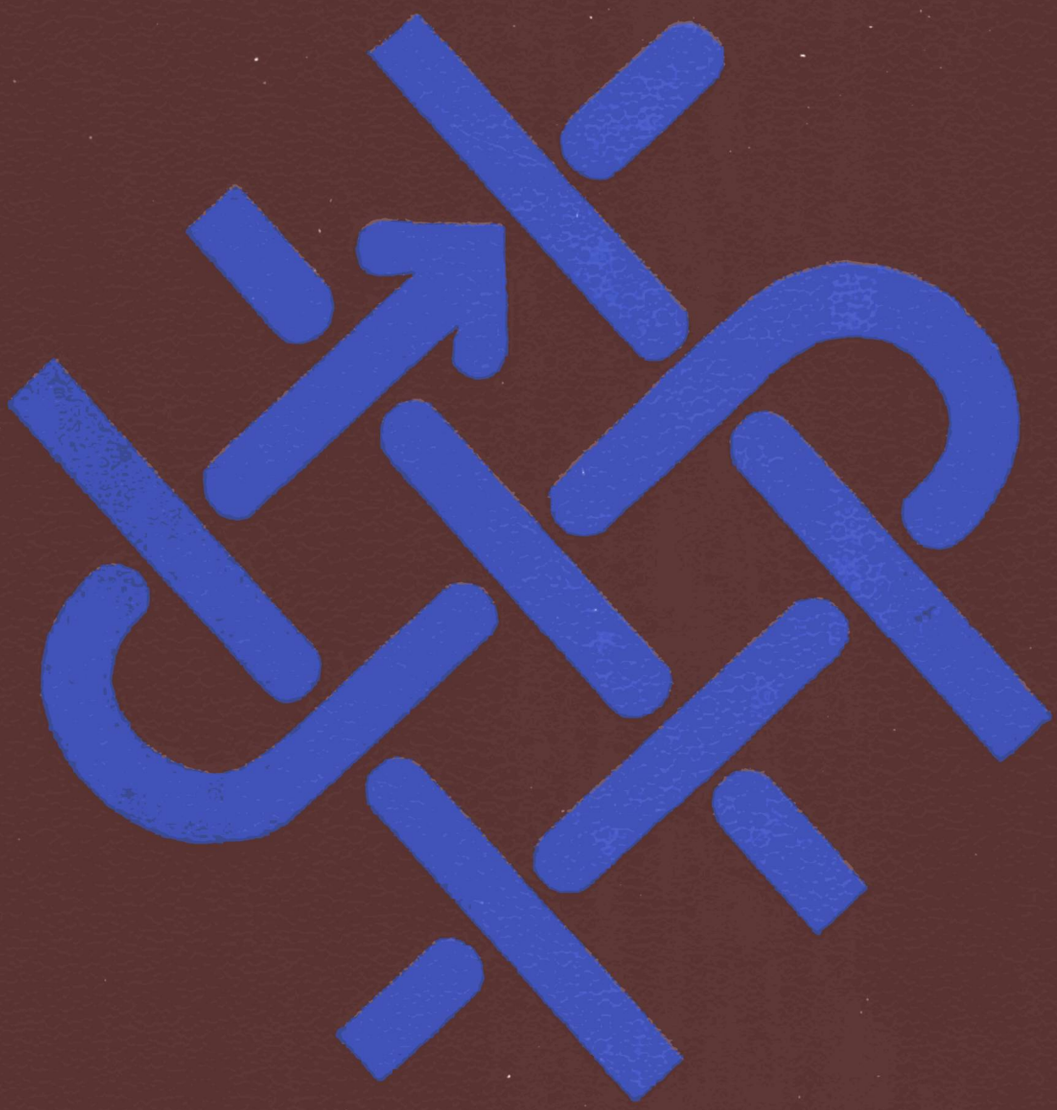
T. GRANOVSKY

Repair and Adjustment of Textile Machines



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T. GRANOVSKY

Repair and Adjustment of Textile Machines

(Spinning and Weaving Equipment)

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The Greek Alphabet

A α	Alpha	I ι	Iota	P ρ	Rho
B β	Beta	K κ	Kappa	Σ σ	Sigma
Γ γ	Gamma	Λ λ	Lambda	T τ	Tau
Δ δ	Delta	M μ	Mu	Υ υ	Upsilon
E ε	Epsilon	N ν	Nu	Φ φ	Phi
Z ζ	Zeta	Ξ ξ	Xi	X χ	Chi
H η	Eta	O o	Omicron	Ψ ψ	Psi
Θ ϑ θ	Theta	Π π	Pi	Ω ω	Omega

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INTRODUCTION

As an important branch of the national economy the textile industry is called on to expand so as to satisfy the needs of the growing personal and industrial use of textiles.

This is possible due to recent advances in the process and engineering developments in all of the fields of production, including good and reliable maintenance and repair.

Modern machinery is characterized not only by high productivity and efficiency, but also by high complexity. A more economical operation necessitates a good organization of technical maintenance and repairs of the available machines and equipment, and their proper adjustment according to prescribed technological procedures.

Referring particularly to textile machinery, it should be said that it works under extremely difficult conditions, i.e. high speeds (the rotational speed of the shaft at open-end spinning is 60 000 min^{-1} and higher), high dynamic loads (such as obtained in scutchers, cards, drawing frames, and looms), etc. The majority of textile machines operate in a dust-laden atmosphere at high humidity. The working organs of textile machines are in direct contact with the processed raw materials which causes machine wear.

The proper lubrication of all rubbing machine parts is always important in order to ensure their faultless running especially under conditions where textile enterprises are working in more than two shifts which results in high loading on the machines.

This causes the accelerated physical wear of working elements, mechanisms and parts of textile machines, and various disarrangements that result in the reduction of labour productivity, machine efficiency, and products quality.

The equipment used at textile enterprises is maintained in good operational condition by adjusters, assistant foremen, repair workers, fitters, oilers, etc. For the same purpose, textile enterprises have various facilities to carry out repair, design and experimental jobs relating to the never-ending search for new methods and more economical operation.

The operation and repair of modern textile machinery involve considerable labour and money inputs. The quality and the costs of machine repairs are greatly dependent on the type of equipment used in repair shops which must be efficient and reduce production costs. However, in order to be more economical, repair and maintenance operations should be performed by highly qualified and properly trained personnel.

The present manual is designed as a study aid for the training of repair and maintenance personnel.

CHAPTER 1

GENERAL NOTES ON DISARRANGEMENTS IN MACHINES

1. Longevity and Reliability of Machines

Terms characterizing longevity and reliability

Serviceability is the state of a machine in which it will give good service (accomplish predetermined functions) under the normal operating conditions. Any disarrangement in machine serviceability is called *a failure.*

The time (in hours) or the volume of accomplished work (in running metres or other units) is called *the output.* In the course of machine operation, a difference is made between the daily and monthly output to the first failure, the output between failures, and so on.

The capacity of the machine to perform predetermined functions, maintaining performance values within preset limits during the required time or output is called *reliability.*

Longevity is the capacity of the machine to give good service (with required breaks envisaged for technical maintenance and repairs) during the time till its ultimate condition specified in the technical documentation.

Resource is the output of the machine during the time till its ultimate condition specified in the technical documentations.

Service life is the length of machine operation till its ultimate condition specified in the technical documentation or till the moment when the machine is discarded.

The following classification has been adopted: service life to first overhaul or medium repairs, service life between overhauls, and others.

Although there is much in common between the machine resource and its service life as they both are determined by its ultimate state, they differ only in the following: the service life is the calendar time of operation, while machine resource is the output till the time of its ultimate condition. With the same machine resource the service life may be different depending on the intensity of machine operation.

Machines used in textile enterprises are constructed from different parts and attachments (auxiliary materials). Some parts are replaced by new ones after the first failure. Such parts are called

non-restorable. To such pertain, for instance, different small axles, rollers, certain antifriction bearings, levers, elements of automatic equipment (diodes, triodes, resistances, condensers, etc.), paper tubes, harnesses, healds, small aprons, nuts, etc. Other parts may have more than one failure in the course of operation. After every failure they are reconditioned (repaired). Such parts are called *repairable.* To such pertain most of the machine parts such as shafts, bearings, fluted rollers, spindles, flyers, cams, ratchets, rods and others.

The capacity of machines to keep serviceability, without forced interruptions, for the time a certain output is produced is called *failure-free performance.* The reliability of repaired machines (parts) considerably depends on failure-free performance, and on *maintainability* which is the state of a machine amenable to failure and disarrangement prevention and elimination. An important indicator of the reliability of the reconditioned machine is its availability factor F_a and utilization factor F_u.

The availability factor (F_a) characterizes a portion of the machine operation time from the total time, for the failure-free operation T and restoration process T_r, i.e. for the elimination of consequences of one failure

$$F_a = T/(T+T_r)$$

The utilization factor (F_u) characterizes a portion of the machine failure-free operation time from the total time of failure-free operation, the process of restoration, and preventive maintenance $T_{p.m.}$ caused by one failure

$$F_u = T/(T+T_r+T_{p.\,m.})$$

The normal operation of the machine is impaired when different kinds of troubles crop up in its parts, conjugated units, assemblies and mechanisms, i.e. wear of friction surfaces, residual deformations (dents and notches, residual sagging, twisting, etc.), breakages, cracks and corrosion defects.

Determining the technical condition of the equipment in operation. In the course of machine operation, its serviceability decreases. This results in frequent disarrangements of mechanisms, assemblies, deterioration of the quality of products, increased rejects, greater consumption of raw materials, lower efficiency, and higher power consumption, noise, knocks, vibrations, etc. When proceeding to the outward examination of the machine the following points are to be established: the degree of contamination of separate parts and assemblies, the proper position of parts, visible traces of their deterioration, loose fitting, deterioration of protection coatings, improper feed of lubricant, and other possible troubles.

Defects of products reveal the kind of disarrangements in assemblies and mechanisms. So, for instance, if the yarn produced in a spinning frame is twitty, this means that there are disarrangements in

the drafting system, such as loose keys in the gears of the drive to the cylinders, broken teeth on the gears of the drive to the drafting system, and the eccentricity of pressure rollers. When in good condition and not subjected to the effect of ambient heat, machine assemblies usually heat up to 40-50°C. Heating-up to higher temperatures occurs due to improper mating of parts, their misalignment, small clearances, high specific loads and poor lubrication.

The general technical condition of the equipment may be assessed indirectly by checking the duration of run-out, or the time of machine self-braking.

The time of run-out or self-braking is the time required for full stoppage of the machine at idle running after drive disengagement.

The longer is the time of self-braking, the lower are the mechanical losses and consequently the power consumption.

When proceeding to the examination of the machine and of the proper mating of its parts, it is necessary to know the maximum increase of clearances for drawing a conclusion whether this conjugation is capable of working or not.

2. Wear of Machine Parts and Improvement of Their Resistance

Types of friction. Contacting parts are subjected to wear under the action of frictional forces appearing at the displacement of parts in respect to each other.

Depending on the nature of the relative motion performed by the friction surfaces, there are three types of friction: *sliding friction* (e.g. shaft in sliding (plain) bearing), *rolling friction* (e.g. against roller cam) and *pivoting friction* (e.g. spindle heel against footstep).

It frequently occurs that friction of one type is accompanied by friction of another type. So, for instance, in gear drives rolling friction between the teeth is accompanied by sliding friction, i.e. there occurs combined friction.

Depending on the kind of lubrication used for rubbing surfaces, friction may be classified as follows: pure friction, when there are no traces of foreign substances on the rubbing surfaces (*pure friction* may be only in vacuum and is not encountered in working mechanisms and machines; *dry* (*static*) *friction*, when the rubbing surfaces are not coated with a layer of lubricant (Fig. 1*a*); *liquid friction*,

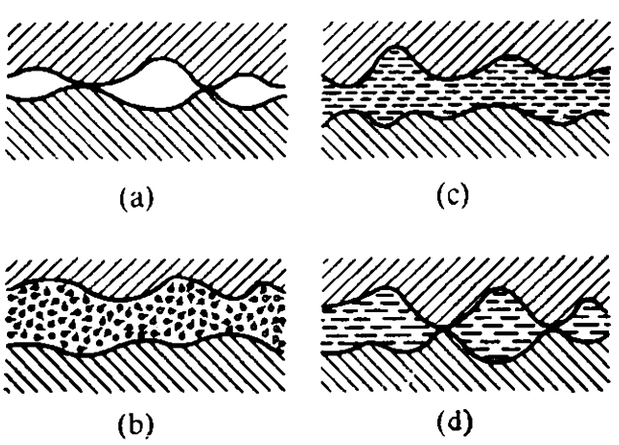


Fig. 1. Kinds of friction

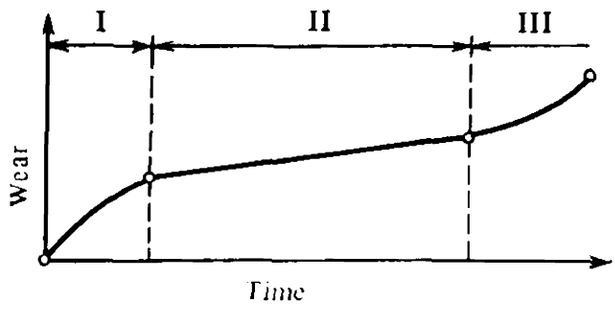


Fig. 2. Diagram of wear

when the friction surfaces are completely separated by a thick stable layer of lubricant (Fig. 1*b*); *boundary friction*, appearing when on the rubbing surfaces there is a very thin strongly adherent oil film (of less than 0.1 μm thin) with properties different from the properties of the liquid layer (Fig. 1*c*); and *semi-liquid friction*, which is a combination of the liquid and boundary frictions (Fig. 1*d*).

Liquid friction (e.g. between shaft and bearing) ensures a minimum wear of parts and power consumption. This is achieved by a higher circumferential velocity of the shaft, a better finish and smoothness of the rubbing surfaces, an optimum clearance, the precise fitting of parts, a good stability of the shaft and the bearing, an increased viscosity and purity of lubricant, an inexhaustible lubricant layer, and an optimum pressure of the shaft on the bearing.

Provided the above-mentioned conditions are satisfied, the lubricant is self-sucked into the gap between the rubbing surfaces, thus causing their separation.

Moreover, liquid friction may be obtained by employing forced lubrication.

Wear and its varieties. Friction is always accompanied by gradual destruction of the surfaces of mating parts moving one upon the other. This gradual destruction is called *wearing*. As a consequence of wearing, there is a change in the original size and shape of the rubbing parts which is termed *wear*. The capacity of the material or parts to withstand wearing is *wear resistance*.

The process of part wear in time is irregular (Fig. 2). During the initial period *I* of machtine operaion, when new parts are run-in, there is a stronger wear; further, comes the period *II* when the speed of wearing is at its minimum, i.e. when the process stabilizes; and finally follows the period *III*, when wear is progressively increasing up to an emergency state so that the part may be brought completely out of use.

The period *I* may be reduced by better finishing of rubbing surfaces, proper assembly of parts, and by using various polishing compositions. The period *II* is prolonged to the maximum by using wear-resisting materials, high quality parts, and accurate assembly, as well as careful maintenance in operation. Owing to regular observation and control over the operation of machines, the friction parts are protected from deteriorating into emergency condition.

There exist the following kinds of wear: mechanical, molecular-mechanical, and corrosive-mechanical wear. Mechanical wear is

produced by abrasive particles that groove and scratch the surfaces, plastic deformation of contacting surfaces, brittle destruction of the surface layer (by work-hardening in rubbing), and repeated deformation causing fatigue deterioration of the surface layers. Molecular-mechanical wear is caused by molecular adhesion on separate spots of rubbing surfaces followed by mechanical destruction of formed bonds and the transfer of particles from one surface to the other. Corrosive-mechanical wear occurs at the formation of products by the chemical interdiffusion of metal with the aggressive agents of the medium, and their mechanical elimination at rubbing. To the corrosive-mechanical wear relates fretting-corrosion which appears due to the oxydation of metal and its abrasive wear by these oxides at very small relative displacement of the conjugated surfaces (for instance, in stationary connections). All working parts of textile machines (such as the fillet needles of all kinds, spikes, saw-toothed fillets, pressure rollers of drafting systems in drawing, roving and spinning frames, runners, etc.) come in direct contact with the processed material (fibre, roving, yarn and others). Most parts subject to wearing by a slipping yarn are intended for guiding the yarn in the required direction (yarn guides), or for creating a required yarn tension (tension arrangements). Depending on the purpose for which these parts are intended, they may be made of metal, plastics, rubber, metal and mineral ceramics.

3. Main Factors Influencing the Wear of Machine Parts and Methods of Increasing Their Wear Resistance

Material of Parts and Quality of Rubbing Surfaces

Material of rubbing parts. Parts are manufactured from different materials, such as cast iron, steel and other antifriction materials.

Cast iron. Gray iron is used in greater amounts than any other construction material for manufacturing the textile machine parts. Cast iron parts come in contact with steel or other cast iron parts and sometimes with parts of nonferrous alloys and nonmetallic materials. They operate under conditions of sliding, pivoting, rolling, or combined friction (for instance, sliding and rolling friction) with or without lubrication, static and dynamic load, etc.

Depending on the working conditions, cast iron must satisfy different requirements. Distinction should be made between the wear-resistant and antifriction cast iron. The cast iron wear resistance greatly depends on its microstructure and particularly its metal base, while the wear resistance of cast iron parts depends on the total amount, shape and nature of graphite segregations (free carbon distribution in the main structure). Graphite plays a double role in the

wear of cast iron parts. As graphite has the less strong structure it may rather easily be picked up to form a thin film on the rubbing surfaces protecting them against contact of metals. Due to the affinity with graphite, lubricating oil is reliably retained on the cast iron rubbing surface and in the recesses formed on graphite pitting. At the same time as it crosses the cast iron metal base, the graphite reduces its strength so that at higher loads particles of metals are torn off in the rubbing process, especially when thick graphite plates mutually intersect and form closed contours. Usually, it is desirable to obtain cast irons with graphite in the shape of middle-sized plates which are separated and regularly distributed in all the metal mass.

The cast iron hardness also affects its wear resistance. The wear resistance decreases with an increase in hardness.

Cast iron wear resistance may be increased by thermal treatment which reduces the cast iron wear by factor of 5 to 7. In some cases it proves necessary to have only wear-resistant surface layers of cast iron parts, while the structure of the core obtained at casting remains unchanged. For this, the cast iron parts are subjected to case hardening by high-frequency current, nitriding, thermal chromizing.

High-frequency current (induction) hardening reduces for instance the wear of parts from ordinary gray iron by factor of 2 to 7. Nitriding, i.e. saturation of surface with nitrogen, imparts a high hardness to cast iron parts (a Brinell hardness of 700 to 800), a good wear resistance (the wear resistance increases by factor of 2-2.6) and the resistance to corrosion caused by the moisture of the ambient atmosphere. The thermal chromizing, i.e. the saturation of the part surface with chromium at the account of the diffusion process (similarly to the saturation with carbon or cementation) increases the surface hardness of cast iron parts almost by factor of 14 and their wear resistance by factor of 6 to 8; moreover, the corrosion resistance is markedly improved. However nitriding and thermal chromizing are used more rarely than induction hardening, as they are time-consuming operations requiring the use of special equipment.

Cast iron parts (such as bosses, rollers, and cams) with chilled surface are sometimes used for textile machinery; in this case the structure contains from 20 to 30% of cementite with a microhardness up to 1000 Bhn. Many parts are made of malleable iron, the wear resistance of which depends mainly on its metal structure.

Steel. In textile machinery the steel parts operate most frequently in conditions of sliding friction in contact with cast iron or bronze parts and more rarely with steel ones; in conditions of rolling friction they operate more frequently with steel parts. With increased carbon content and at greater hardness of the steel its wear resistance increases. Heat and chemical treatment of steel also considerably

increase the steel wear resistance both at sliding friction and rolling friction; the lower is the temperature of tempering after hardening, the lower is the steel wear

The heat treatment of metals, ferrous and nonferrous and plastic materials is intended to obtain certain desirable conditions and properties, especially in the nature, form, size or distribution of the structural constituents. The main kinds of thermal treatment are annealing, hardening, tempering and so on.

Annealing involves changes in the direction of the restoration of the properties of a cold worked metal obtaining before cold deformation at various annealing temperatures, with time period of annealing being constant or variable. Annealing increases the relative elongation and the impact strength of steel.

Hardening implies the heating of steel to a temperature exceeding the critical temperature, keeping it a certain time in these conditions followed by sharp cooling (quenching). Hardening with subsequent tempering is effected to increase the hardness of tool steel, impart wear resistance, strength, and endurance to structural steel, to increase the corrosion resistance of anticorrosive steel and also as a preliminary operation before chemical and thermal treatment. The quality of hardening depends on the speed and temperature of heating, the time of processing and the cooling speed. When the mass of the part is big and the steel heat conductivity is low the speed of heating is slow. Parts of alloyed steel should be heated slower than those of carbon steel as the heat conductivity of alloyed steel is lower. Parts of large dimensions (with thick walls) should be heated slowly. Heating is carried-out progressively together with furnace heating.

In certain cases the parts are preliminarily heated to a temperature slightly lower than hardening temperature in another furnace or close to the door of the furnace used for heating at hardening.

Tempering is a heat treatment of steel which follows hardening, carburizing and cyaniding (case hardening), removes stresses, increases ductility and impact resistance, and decreases the tensile and yield strengths of the hardened material. Moreover it is treated by cold.

The main kinds of chemical and heat treatment of steel and cast iron are carburizing, cyaniding, nitriding, aluminizing and chromizing. The chemical and heat treatment of metals and alloys is effected by their heating and keeping at high temperature in active solid, liquid, and gas mediums. Parts and tools are chemical and heat treated to increase their surface hardness and resistance with the tenacity (ductility) of interior layers preserved unchanged. Some kinds of chemical and heat treatment should be followed by other types of heat treatment (for instance, carburizing is followed by hardening and tempering, etc.). Some kinds of chemical and heat treatment ope-

rations are designed to increase the corrosion resistance of parts and tools.

Carburizing is a process that introduces carbon into a solid ferrous alloy by heating the metal in contact with a carbonaceous material — solid, liquid, or gas—to a temperature above the transformation range and holding at that temperature. Carburizing is generally followed by quenching to produce a hardened case at a temperature of 780-800°C with subsequent tempering at 180-260°C. This ensures a high wear resistance of the surface layer.

Cyaniding is a process of case hardening a ferrous alloy by heating in a molten or solid cyanide thus causing the alloy to absorb nitrogen and carbon simultaneously. Depending on the level of temperature used, the process falls into high and low temperature cyaniding (800-860 and 550-660°C, respectively), and depending on the kind of medium—in liquid gas and solid medium cyaniding.

Nitriding is a process that saturates alloyed steels and cast iron with nitrogen by heating parts in ammonia atmosphere. Prior to nitriding, steel is subjected to heat treatment. The aim of nitriding is to increase the hardness, wear resistance and fatigue strength of machine parts.

Aluminizing is a process of saturating steel and cast iron with aluminium for increasing their resistance to scale formation. Aluminizing is mainly used for low-carbon steel, for gray iron and high-alloy heat-resistant steel. Aluminizing is used to increase the useful life of parts operating at high temperatures (for instance, pressure casting moulds for non-ferrous alloys, grid bars, steam boiler pipes, valve heads, etc.). Aluminizing is carried out in hard powder compounds and in a melted aluminium alloy, by metallization of the surface with subsequent diffusion annealing, and by other methods.

Chromizing is a process of surface saturation of steel or cast iron parts with chromium in order to increase their corrosion resistance and surface hardness; so the wear resistance of chromized steel is ten times that of the same hardened steel. Textile machinery parts are made from carbon, medium- and low-alloy steels (mainly manganese and chromium steel). The wear resistance of steel depends on the methods of its manufacture and hot treatment. Acid and open-hearth steels are more wear resistant than basic steels; crucible and electrical steels have a more uniform structure and are more wear resistant than Bessemer and open-hearth steels. At hot treatment by pressure (forging, stamping, and rolling) owing to the consolidation and splitting of grains in steel (especially in exterior layers) the wear resistance as compared with cast steel is increased.

Antifriction materials. To such relate: nonferrous antifriction alloys, antifriction carbon-iron alloys (cast iron), cermet (metal ceramic), and nonmetal antifriction materials.

Antifriction property is the material property which in metal-to-

metal rubbing ensures the smallest friction factor with all other conditions being equal (speed, kind of lubrication and applied load).

The antifriction materials, used for manufacturing bearings, should work well with materials of other mating parts, should exhibit good wear resistance, high mechanical and technological properties, good thermal conductivity and corrosion resistance; and should be able to absorb the products of wear.

Nonferrous antifriction alloys. Most of these alloys have approximately the same structure — a plastic mass with embedded hard particles. During operation the soft mass wears more rapidly than the hard particles and as a result a microrelief is formed with protruding hard particles which carry the mating part, such as shaft in bearing. The oil circulates easier along the formed canals and cools quicker the rubbing surfaces carrying-away with it the products of wear.

To nonferrous antifriction alloys relate: babbitts, antifriction bronze, brass, zink and aluminium alloys.

The babbitts are subdivided into the tin-base, lead-base and cadmium-base babbitts. They are used for lining in bearings.

Bronze and brass are copper-base alloys. Bronzes are subdivided into casting and wrought bronzes as well as tin and tinless bronzes. Tin bronze is used for bearings (linings, bushings) operating under loads not over 5-8 MPa, average speeds (up to 3-4 m/s) and normal temperatures. Tin bronze may take impact loads (up to 15-25 MPa) and high speeds (up to 8 m/s). The aluminium-iron bronze is used at high temperatures (up to 200-250°C) and under high loads.

Aluminium ferrous-manganese brass and silica-lead brass are used for parts operating under high specific loads (up to 10-30 MPa) and at slow speeds (3-4 m/s). Parts wearing against brass (shaft necks and worms) should have a hardened surface (by nitriding, cementation, and hardening).

Zinc-base alloys have a high linear expansion factor so that the clearance between the bearings made of such alloys and shaft must be increased. Aluminium-base alloys are used to replace babbitt and tin bronze for linings in cast iron and steel bodies and for casting linings and bushings; however minding the high linear expansion factor of these alloys the clearances must be increased.

Antifriction carbon-iron alloys. Antifriction cast iron presents a high wear resistance, good casting properties but is more difficult to run-in than bronze. Antifriction cast iron is subdivided in gray, high-strength, and malleable grades. All these grades of cast iron are successfully used for manufacturing different kinds of liners, bearings and other sliding bearers operating at steady or alternating loads. In case of impact loads, it is recommended to use malleable antifriction cast iron presenting a high strength (σ_t = 480...550 MPa) and a toughness of δ = 4...6%.

In order to ensure the normal operation of antifriction cast iron parts, the rubbing parts must be of high smoothness and perfect mating, the lubrication must be reliable and the clearances must be 15% greater than those in the bronze bearings.

Cermet (metal ceramic) materials. The cermet parts (bushings, linings, etc.) are made by pressing mixtures of metal powders with additives acting as hard lubricants in die casting moulds and cintering in protective or neutral gas medium. Usually iron or bronze powders are used, and more rarely copper, aluminium, or titanium powders. Mainly graphite and more rarely sulphur are used as additives. The parts of metal ceramic materials are distinguished by their porosity and consequently by high antifriction properties and wear resistance.

The use of porous bearings in textile machines is highly expedient, considering that they are capable of operating a long time without additional lubrication. Not long ago a new material—a metal-base laminate—has found application; it is obtained by sintering a bronze spherical powder loosely strewn on a steel ribbon with copper plated surface. The life of parts made of such a metal-base laminate by swaging is twice longer than that of parts made of usual metal ceramics. In use such parts do not require any lubrication and are called for this reason dry friction bearings.

Polymer materials. These materials are easily run-in and are endowed with low wear, high damping property, etc. Polyamide materials (capron, cylon, perlon, caprolon, polyamide resins, amide, and nylon 66) are used to manufacture bearings operating without exterior lubricant supply at a temperature not in excess of 85°C in dust-laden atmosphere and under impact loads.

Their main drawbacks are humidity absorption causing a change in part dimensions and low thermal conductivity. The properties of the antifriction polyamide material are considerably improved by the introduction of fillers (graphite, talc, etc.). Capron filled with graphite is with low humidity absorption and ensures a good stability of dimensions being characterized by high strength and hardness. The following polymer materials also find use: polyformaldehyde, acryloplastics, epoxy plastics, etc.

Plastic materials on a wood and cloth base. To such pertain laminated wood plastics, compressed wood, fabric-based laminate, and others.

The laminated wood plastics contain a binder—a bakelite varnish in which the phenol formaldehyde resin is dissolved in ethyl spirit.

Laminated wood plastics are used for manufacturing large-size bushings, lining, gears and other parts which were produced before from nonferrous and ferrous metals, fabric-based laminate, and other materials.

To improve the antifriction properties of the rubbing surfaces of these parts, 7-10% of graphite are introduced in their surface layers, and to increase the thermal conductivity—a metal powder (bronze, aluminium, copper, and lead).

Plasticized wood is produced by piezothermal processing (by application of pressure with heating), the aim of which is to condense the wood. Hard wood is used to manufacture rubbing parts (birch, asp, alder, beech, maple, and hornbeam).

Compressed wood is capable of absorbing lubrication oil. After impregnation in hot machine oil (at a temperature of 80-100°C) the parts of compressed wood become selflubricating. Parts of compressed wood easily absorb oscillation and are capable to withstand high impact loads. Moreover, the part (shaft) operating in couple with the part made of compressed wood (bearer) wears less than in rubbing against any other material. Parts of compressed wood are easily worked in. Liquid and consistent mineral oils and greases may be used for their lubrication.

Fabric-based laminate is a material obtained on the base of a cloth impregnated with resol resin. As cloth may be used chiffon, plain and grey cloth, duck; linen fabrics and fabrics of synthetic fibres are used more rarely. Its mechanical properties depend on the kind of fabric weave and on the direction of the load in relation to the disposition of layers. Fabric-based laminate is produced in sheets (up to 8 mm thick) and slabs (thickness more than 8 mm), as well as rods and pipes.

All-use and metallurgical fabric-based laminates are used for manufacturing bushings, bearers, gears and other loaded parts operating in couple with metal parts.

There are available also plastic materials on the base of phenol-formaldehyde resin with cotton fibre (voloknite), asbestos fibre (asbovoloknite), and glass fibre (glassvoloknite, or glass-fibre-base laminate). The friction factor of these plastics is reduced by introducing in their compositions such fillers as graphite, fluoroplastic and others.

Quality of rubbing surfaces. Characterized by macro- and microirregularities and waviness.

Microirregularities are located inside a square with a side of about one or several millimetres. The microirregularities in the direction of the cutting tool motion are called longitudinal irregularities and those in cross direction (perpendicular to the longitudinal ones)—transverse irregularities.

Macroirregularities are nonrecurring separate deviations of the surface from the nominal shape (conicity, ellipticity, nonflatness, convexity, concavity, etc.).

Waviness is a combination of recurring in alternate order peaks and valleys of nearly the same dimensions and forming irregularities

spaced at much larger distances than in case of microirregularities. Waviness has the following effect on the wear: with an increse in the wave height the wear increases, but at the same time the scoring resistance of the rubbing surfaces is improved.

The initial condition of the part (surface quality) changes in the course of operation (or wear). During machine parts working-in, the initial surface irregularities formed at machining are completely or partially eliminated, worn out and crushed; new irregularities appear with different shape, dimensions, and direction. If the conditions of wear remain the same after working-in of the part, new irregularities differing from the initial ones appear on its surface.

Quality of Machine Assembly, Operating Conditions, Lubrication and Maintenance

Quality of machine assembly. Mistakes made during machine assembly affect the wear resistance of parts. Canting shafts, overtight bearings, misaligned multiple-seated shafts, improperly meshed gears, incorrectly matched cams, poor balancing of rotating parts may become a cause of the rapid wear of machine parts.

A canting shaft at the beginning adheres only to the edges of the bearing so that a high specific load created at this point causes an intense heating and wear of parts. It should be taken into account that in case of shaft canting the liquid friction is impossible. If the shaft is of low rigidity, i.e. it may be easily bent, it is liable to be canted in the supports during operation even if the assembly has been done correctly. In this case self-adjustable bearings are used.

Overtight bearings caused by high friction would result in the enhanced scoring of shafts and hard (bronze, or cast iron) linings or in the melting of the babbitt lining, including other troubles. At enterprises where there is a strong dust formation the strong heating of bearings may be the cause of fire especially when oil has a low ignition temperature.

Improper meshing of gears is due to the non-observance of radial and side clearances, the non-parallelism of axles and others. Such mistakes cause the teeth to contact over a small surface, increase their slipping, cause poor rolling and the rapid wear of gears. Skewness in meshing is frequently the main cause of gear teeth chipping out and breakage.

Improper balancing of heavy rotating parts (e.g. cylinders of card, drawing, warping, and sizing machines), causes a strong vibration and rapid and nonuniform (one-side) wear of the shaft and bearings.

Mode of operation. Frequent stoppages of textile machines during operation (e.g. in case of thread breakages) have a serious influence on the wear resistance of parts: the more often the machines are stopped, the lower is the wear resistance of parts. At each new star-

ting of the machine after stoppage its assembly units have to overcome the inertia of rest and consequently the load on the units increases. On machine stoppage, the displacement speed of rubbing surfaces is sharply reduced causing a loss in the oil lubricating capacity. Therefore, a reduction in yarn breakage and in the time needed for breakage elimination not only ensures an improvement in machine efficiency and product quality, but also increases the wear resistance of the equipment.

Lubrication of machines and their maintenance. As mentioned above, lubrication is intended for reducing the wear of machine parts. The effect obtained by lubrication in increasing the wear resistance of parts is considerable. For instance, lubrication brings about more than a 5-fold decrease in the wear of cast iron linings which were not worked-in, and of worked-in linings—more than 30 times.

The lubricants are chosen taking into account the speed and design parameters of the parts. Thus, for instance when the choice is made for a couple *shaft — bearing*, the following factors shall be considered: the load, rotational speed of the shaft, clearance, thickness of lubricant layer, shaft diameter, and ratio of the bearing length and diameter.

The most important properties of lubricating oils is their viscosity. The greater are the load applied on the rubbing couple, the clearance, and the thickness of the lubricating layer, the higher must be the oil viscosity; the greater are the shaft rotational speed and diameter, and the ratio of the bearing length and diameter, the lower should be the oil viscosity. It must be taken into account that viscosity is not a stable characteristic which depends in a large measure on the temperature of the liquid lubricant and on the pressure. With an increase in the temperature, the viscosity is sharply reduced, especially in the temperature range from 0 to 40-60°C. Further, this drop in viscosity slows down, and at the temperatures above 80-100°C viscosity changes but little. With an increase in the pressure, the viscosity of the liquid lubricant increases, this change being essential only at considerable pressures.

Alongside with the proper choice of oil, the wear resistance of rubbing parts depends in a large measure on careful maintenance.

The lubrication and cleaning of machines must be carried out in accordance with the manufacturer's requirements. In case of their violation the wear of machine parts and power consumption increase. For example in the case of flax spinning machines this increase is from 1.5 to 4 times, i.e. 20-35% correspondingly. The lubrication chart of a scutcher is given in Table 1.

To increase the wear resistance of parts operating with insufficient lubrication (some units of textile machines are insufficiently lubricated considering the possibility of contaminating the web, roving, yarn and fabric with oil) use is made of special lubricants, in

Table 1. Scutcher Oiling Chart

Lubrication point	Lubricant	Periodicity of lubrication
Centralized lubrication (oil replacement in distribution boxes)	Industrial oil	Once per shift
Spur reduction gear	Ditto	Three times a year
Worm reduction gear	Winter automobile transmission oil	Ditto
Slide friction bearing with individual lubrication	Industrial oil	Once per shift
Gear teeth	Grease	Twice a month
Beam oiler	Emulsion for fibre humidifying	Three times per month

particular graphitized oils and oils with molybdenum disulphide.

Graphitized oil is an ordinary acid-free mineral oil containing 1-2% of fine ground graphite of lamellar structure and characterized by a high mobility of its layers owing to which it has a low friction factor. The wear of such parts as cast iron bearings and shafts due to the use of this oil is reduced from 3 to 4 times as compared with the wear of the same parts when ordinary mineral oil is used for the purpose. Moreover, the consumption of graphitized oil is twice smaller. It should be also noted that parts lubricated with graphitized oil are not subject to corrosion.

Oils with molybdenum disulphide are used for the lubrication of different friction units (tooth and worm gearings, rings and travellers, spindles, etc.).

Greases containing molybdenum disulphide are mainly used for plain and antifriction bearings. Molybdenum disulphide is used as powder, paste, and varnish for coating the rubbing surfaces of parts by different methods (by spraying, by applying it with a brush, etc.).

In the case when an ample lubrication is for some reason unnecessary, porous metal-ceramic, or iron-graphite parts are used. The porosity ensures a good relief of the surface, better lubrication, and the possibility of self-lubrication of parts (at low speeds and loads).

4. Break-downs of Machine Parts

The break-downs of machine parts are mainly caused by overloads. They may be due to improper threading and gaiting of looms (when a light loom is gaited to produce a fabric with a high filling factor), improper balancing of rotating heavy parts (the drum of a section warper), low quality of manufactured and repaired parts and equipment, including poor maintenance of textile machinery.

Variable loads may cause more frequent breakdowns of parts. This phenomenon is called the fatigue deterioration (destruction) of materials. Fatigue break-downs occur suddenly without visible manifestations. This may often be the cause of the deterioration of other machine parts and break-downs of different kinds.

The fatigue strength of parts is determined by the character and the intensity of variable load, the shape and dimensions of the part, the character of mating parts and the quality of their surface, the extent of corrosion, and the mechanical properties of the material from which the parts are made, their amenability to notching, and the technological process of part manufacturing.

Character and intensity of variable load. The variable load acting on the part causes alternating stresses. Any single change in the stresses is called a cycle. The time during which the cycle is effected is called a period, and the number of cycles performed per unit of time (e.g., one minute) is called the cycle frequency.

The maximum stress at which the material is not destructed at the unlimited number of cycles is called the endurance limit, or the fatigue limit. At testing, this stress is set to 10-20 mln cycles for steel, and 50-100 mln cycles for nonferrous metals. If the part withstands the indicated number of cycles without cracking, it means that it is capable of withstanding an infinitely great number of cycles.

Overloading of parts affects in different ways the fatigue strength. With light overloads an increase in strength is observed, while with great overloads the strength is reduced. If the stress is close to the endurance limit of parts which are not subjected to a constantly growing variable load, the fatigue resistance may considerably rise. This phenomenon is called the training of material. Consequently, working-in and running-in of assembled machines are necessary not only for working-in the rubbing surfaces of parts, but also for their training under the conditions of variable loads.

In case of considerable overloads, i.e. stresses greatly exceeding the fatigue limit, the ability of metal to work without cracking under the action of cyclic loads, that is its endurance, noticeably decreases. To reduce the danger connected with fatigue break-downs of parts due to overload, it is necessary to carefully balance the rapidly rotating parts, to eliminate out-of-true and misalignment of parts, to adjust the dampers of impact loads, to use vibration dampers, to check the proper mating of parts, to check regularly and to tighten slack fixtures, to adjust the clearances between rotating parts avoiding operation with big clearances, etc.

Shape and dimensions of parts. The fatigue destructions are usually observed at the points where the part sharply changes in shape, as for instance in keyways *4*, threads *3*, head pieces *2*, holes *5* and *6*, steep steps *1* (Fig. 3), etc. In such places, stresses are concentrated

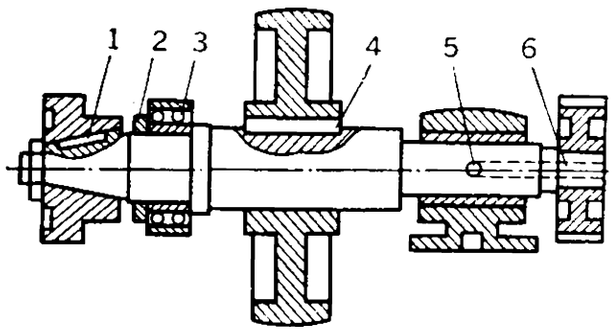


Fig. 3. Fatigue destruction of machine parts

to become many times greater than the stresses in the smooth section of the part. The presence of concentrated stresses greatly reduces the endurance limit of the part.

As is known, the endurance limit of the part decreases with an increase in its diameter. This relates to various metal properties and the effect of a sharper drop of stresses from the exterior case-hardened and harder layers towards the inner layers which have not been subjected to hardening. For reducing the causes of fatigue and break-down of parts it is necessary to smooth down all the places where the stresses are apt to concentrate; so for instance it is efficacious to round off all the steep steps.

Moreover, these points should be work-hardened to create compressive stresses. Thus, the thread obtained by knurling has a longer life than the thread obtained by cutting.

Conjugation of parts. Close fits affect the fatigue strength more than all other factors: the fatigue strength may be decreased four times and more (the greater the interference, the less is the fatigue strength). At the same time the fatigue strength greatly depends on the kind of material from which the mating parts are made and on the kind of their conjugation. So for instance, the fatigue strength of the shaft decreases with the increase of the bush hardness; a longer or thinner hub, annular grooves on the butt of a pressed-on part, including the fit of parts on a special shoulder (thickening of the shaft) and the surface knurling of the shaft to fit parts are the factors which cause a decrease in the strength concentration.

Quality of part surface. The higher is the surface finish of the part, i.e. the less is its roughness, the greater is the fatigue resistance of the part. Stresses are concentrated on the rough surface of parts (in the cavity of every notch) which causes a decrease of its fatigue strength. Even inconsiderable scratches on a polished surface may cause a decrease in the endurance limit to 40%. Therefore, in repairs, the parts are subjected to artificial work-hardening owing to which their fatigue strength is increased from 1.5 to 2.5 times.

Corrosion. The surface corrosion of parts causes a considerable decrease in their endurance limit. The destruction of parts by corrosion is called corrosion fatigue. It increases when there is a concentration of stresses and the parts work in a more corroding medium, when the parts work in tension and compression, when the surface is coarse and the number of applied cycles is increased.

The anticorrosive coatings of the parts differently affect the cor-

rosion fatigue. The coatings obtained by electrolytic chromium, copper and nickel plating, as well as sulphurizing reduce the corrosion fatigue, while the coatings obtained by zink plating eliminate the harmful effect of the corroding medium on the fatigue strength. Moreover, anticorrosive (short time) nitriding, spinning with rollers, and blowing with shots are also used to avoid the corrosion of machine parts.

Mechanical properties of part material and its notch sensitivity. The more homogeneous and pure is the structure of the material used for part manufacturing, the higher is its endurance limit. The notch sensitivity increases with endurance limit. Notches decrease the endurance limit of steel by 35-55% and of cast iron by 5-20%.

The fatigue strength of metals is greatly affected by their capacity of absorbing and damping oscillations appearing during machine operation (cast iron parts are in this case preferable to steel parts).

Technological process of part manufacturing. The fatigue strength of parts depends on many technological factors encountered during manufacturing and repair operations, i.e. the kind of metal cutting, rolling, forging, welding, metal coating, electroplating, heat treatment, or thermal chemical treatment.

During the process of cutting not only irregularities are formed on the surface, but also there occurs work-hardening of surface layers. Rolling effected by means of steel hardened rollers increases the fatigue resistance. The effect of forging on the steel strength depends on the direction of load application: the change in the amount of reduction by forging slightly affects the static strength and the impact strength of steel with the grain, while when the forging reduction ratio increases the impact strength of steel across the grain is considerably reduced. Consequently, the fatigue limit is less across the grain than with the grain. Concentrated stresses have also a stronger effect on the longitudinal grain than upon the traverse ones.

Welded and built-up parts present a smaller endurance limit than whole parts made of the same metal. The endurance limit depends on the method of welding. Electric arc welding ensures a higher endurance limit than gas welding (especially when heavy-coated electrodes are used); automatic welding permits us to obtain joints with better endurance than manually welded joints; forging, annealing, machining and rolling of built-up metal also increase its endurance limit. The highest endurance limit is obtained at contact flash welding.

The sprayed metal coating at conjoint operations with the base increases the endurance of the main metal by 15-20%. Electrolytic coating, i.e. chromium, nickel, and copper plating, decreases the endurance limit of parts which is the more reduced, the greater is the coating layer. Heat treatment (hardening) increases the endurance limit of parts. The fatigue strength of parts is considerably increased

by heat hardening with high frequency currents and also at thermal and chemical treatment—by carburizing and nitriding. Hardening with current of high frequency is especially efficacious for parts with cuts, cross holes and provided with close-fit bushings and other points of stress concentration. In these cases the endurance limit of steel parts may be increased 1.8-2.5 times. The endurance limit is two-fold and more increased by carburizing and nitriding.

REVIEW QUESTIONS

1. What is understood by machine serviceability? Give examples.
2. Determine the longevity, useful life, availability factor, and utilization factor of machines.
3. What parts or machines are considered as capable of being repaired or non-repaired?
4. How are the kinds of friction classified?
5. What kinds of wear are known?
6. What are the factors affecting part wear?
7. What are the methods used for increasing the part wear resistance?
8. What materials are classified as antifriction?
9. What is cermet or metal ceramics? What is the application of parts made of metal ceramics?
10. What plastic materials are used in textile machinery? Give their description.
11. What is the purpose of lubrication? Describe the kinds and modes of machine lubrication.
12. What are the causes of machine parts breakage?

CHAPTER 2

METHODS OF MACHINE PARTS RESTORATION AND INCREASING THEIR LONGEVITY

Parts which in course of operation have lost their essential properties (dimensions and shape), with breakages etc., may be used for further operation after repairing.

Any parts with different defects and disarrangements may be repaired. However, not all defectuous parts are repaired. The need of repair and the choice of the methods applied at the repairs are determined by economic considerations which are the cost of repairs and the longevity factor of the part.

Modern technological processes used to restore parts not only allow the restitution of the parts, but also permit imparting them properties better than in the original parts.

The advanced experience shows that the best effect in part restoration is achieved in series production using modern technology. Therefore, the restoration of mass parts (mainly) should be carried out in a special shop servicing one or several enterprises of the same type.

During repairs the initial dimensions and shape of parts are restored (repair of worn-out gear toothing), including fits and tolerances (clearances between shaft and bearing). For this purpose use is made of the following operations: insertion of intermediate bodies, application of pressure, welding of surfaces, metal coating, chemical and heat treatment, spark machining, glueing, soldering, and others. These processes can be used separately or in combination, as for instance welding with metal coating.

1. Repair of Parts by Mechanical Methods and by Plastic Deformation (Pressworking)

Mechanical methods of repair. To the mechanical methods of repairing defective parts pertain: ringing (placing rings), the use of stitches or straps, patches or inserts and repair sizes. The first three methods ensure the restoration of design sizes of parts, force or shrink fits, while the latter process is employed only to ensure force or shrink fit.

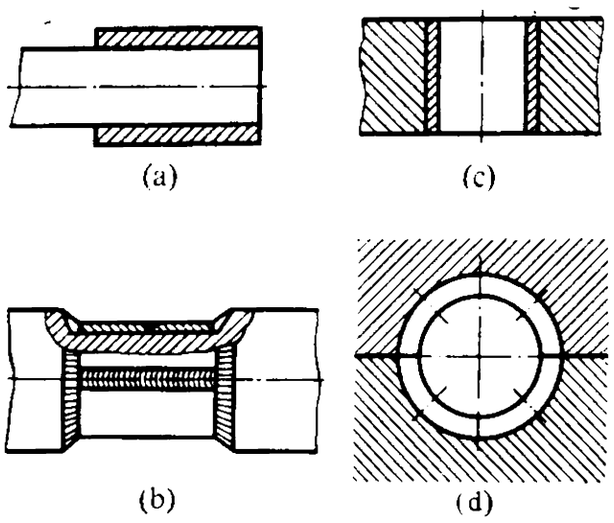


Fig. 4. Ringing of defective parts

Ringing is the restoration of parts by placing rings on worn-out cylindrical surfaces. Ringing may be exterior (Fig. 4*a*, *b*) and interior (Fig. 4*c*, *d*). Exterior ringing is used to restore shaft journals, and interior ringing—to restore different holes, as for instance in the body, framework, bushing, solid bearings, etc.

The reliable fitting of rings depends on the diameter of mating, the circumference of the ring, the contact pressure, and the friction factor. Rings may be placed with the aid of a press machine; by preliminary heating of a ring (in the case of exterior ringing) or heating of the part to be restored (at internal ringing); by preliminary deep cooling of a ring (in the case of interior ringing), or of the part (at exterior ringing).

Hot ringing ensures a better strength of the joint, as compared with the other methods. Moreover, the strength of joint between the ring and the part is influenced by the surface finish. For increasing the fatigue strength of parts restored by exterior ringing, the surface of the parts on which the ring is to be placed should be work-hardened or subjected to short-time nitriding. In case of excessive stresses, the negative allowance is reduced, the ring is welded around and work-hardened by means of a roller. When restoring the crankshaft rod nuts and split antifriction bearings, half-rings (half-bushings) are used. They are attached by welding, screws, and by other methods. In the case of exterior ringing, steel and cast-iron rings are employed, while for interior ringing bronze rings find application.

Stitches or straps are used to stay the broken part. On the both sides of the crack *T*, holes are drilled in which dowels *1* (Fig. 5*a*) of the heated strap *2* (stitches or straps) are introduced; after cooling the strap tightens the crack. The number of straps used depends on the length of the crack. The distance between the holes must be smaller than the distance between the dowels (in a cold state), by the amount of interference fit.

The tightening straps may be of different shape: H-shaped (Fig. 5*b*, *c*), round (Fig. 5*d*) or oval (Fig. 5*e*).

Inserts or patches are used for repairing shafts (journals and necks), gears (toothing), cams (tips) and others. According to this method, a new portion is placed instead of the worn-out or broken portions of the parts. The inserts or patches are attached to the part with the aid of thread, cone, dovetail and others, usually by welding.

The use of repair dimensions is effected as follows. If, for instance, the shaft with the design diameter d_d has been worn out to the value of z_{sh} it is subjected to turning and grinding to a new smaller size by removing the layer Δ_{sh}. The new diameter $d_r = d_d - (z_{sh} + \Delta_{sh})$ is the repair size. A new bearing is to be manufactured for the shaft with a new repair size. The shaft and bearing must have the same tolerances as for new parts, so that fitting and interchangeability of restored parts are obtained. The part may have several repair dimensions which are employed in certain sequence. A scale of repair sizes may be established for an expensive unchangeable part of the conjugation, as for instance for a shaft, or for preparing a stock of cheaper replacements as for instance bearings. This would considerably accelerate repair operations.

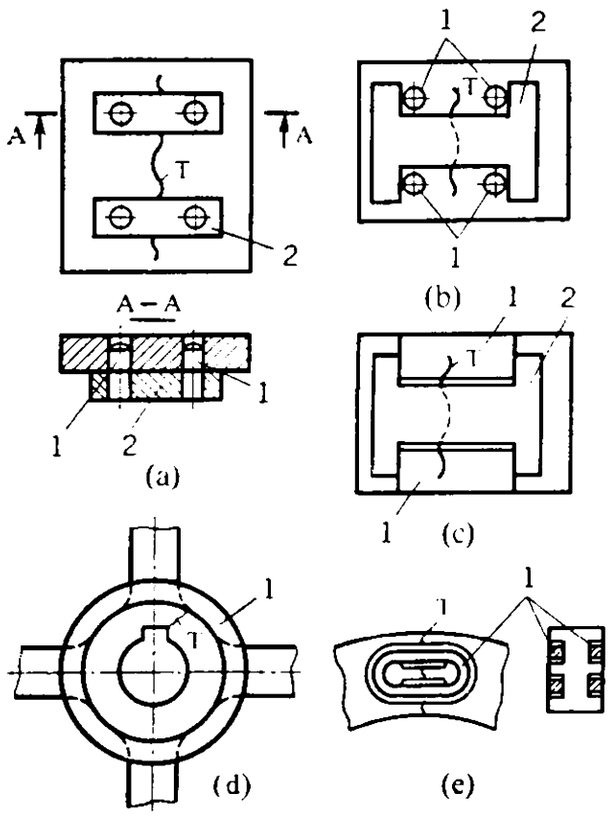


Fig. 5. Use of tightening devices to repair cracked parts

Plastic deformation (pressworking). This method is used to repair parts of simple shape, as well as parts made of maleable materials (steel, brass and soft bronze). Depending on the direction of the forces acting at pressure and deformation in respect to the centre line of the part to be restored, the repairs may be classified as follows: heading, flaring, reducing, forcing-in, knurling, rolling and straightening.

Heading is used to reduce the interior diameter of a hollow part (or bushing) or to increase the exterior diameter of a whole part (finger or stud). The direction of the deformation b is perpendicular to the direction of the exterior effort T (Fig. 6*a*).

Flaring is used to increase the exterior diameter of a hollow part by spreading it from inside. The direction of the deformation coincides with the direction of the exterior effort (Fig. 6*b*).

Reducing is employed to reduce the exterior and interior diameter by applying an external effort to the outer cylindrical surface of the hollow part (bushing). In this case, directions of deformation and of the applied efforts coincide (Fig. 6*c*).

Forcing-in is an operation combining heading and flaring which is used to increase the outside diameter of solid flat parts. Forcing-in

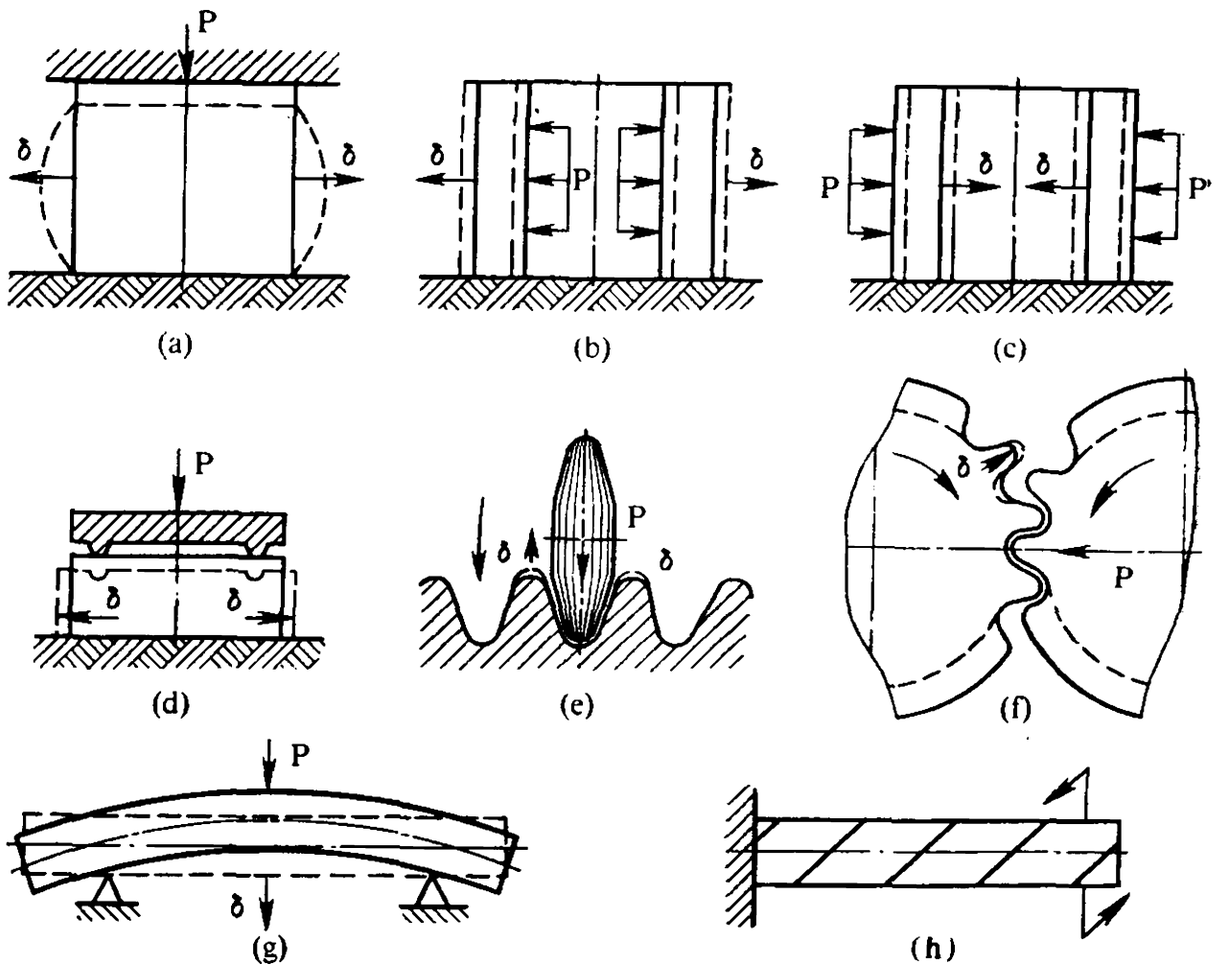


Fig. 6. Diagrams of machine part repairs by plastic deformation

is achieved by the application of concentrated forces (Fig. 6*d*).

Knurling (Fig. 6*e-f*) is the process of plastic displacement of metal by pressing a steel roller into the corrugations of the part to be restored. When restoring fluted rollers, a steel roller is forced into cavities between the flutes, and its rolling along the recess of the worn-out flute displaces metal from hollows to the crest.

Rolling. One or several easily rotating rollers with a smooth surface of hardened steel or hard alloy are pressed to the rotating cylindrical part lubricated with oil. The rollers are imparted not only with a rotational, but also with a translatory motion (along the surface of the part). The metal on the surface of the part is redistributed, and work-hardening of the surface layer takes place.

The apertures of the parts to be restored are brought to required dimensions by punching with a mandrel or a ball, and also by expanding with a special tool. Finishing with rollers, calibration, and expansion also use the process of the plastic deformation of the surface metal layers.

To ensure the plastic deformation of parts by rolling the portions to be deformed are subjected to electric heating. This method is called electromechanical treatment.

Straightening (Fig. 6*g*, *h*) is the restoration of a part which became bent or twisted in the course of operation. Straightening may be carried-out on cold and hot parts (the latter method is used in case of strong bending of the part). The accuracy of cold straightening is higher. Since the required sizes are not always obtained after cold straightening, it is recommended to carry out stabilizing, i.e. heating of the parts after straightening to 400-500°C.

Steel parts which are slightly bent are also straightened using surface cold-working. This kind of straightening is used for the repair of shafts, axles, knives, beams, guides, cylinders, and other parts.

Stamps or special jigs and fixtures are necessary to carry out heading, flaring, reducing and pressing-in operations performed on press machines. Knurling requires special knurling devices which are mounted on lathes, planing or other special machine tools. Straightening is done on presses or special devices.

2. Welding and Building-up

There are two kinds of welding: fusion welding and pressure welding (plastic). To fusion welding pertain arc welding and gas welding. Pressure welding may be classified into resistance welding (butt welding, seam welding and spot welding), gas pressure welding, and forge welding. The electric arc welding and gas welding are used for the repair (joining) of broken and cracked parts of steel, cast iron, bronze and other metals and alloys; the electric butt welding is used for butt joining of broken parts of steel and other plastic materials; electric spot welding and seam welding are used for overlap joining of sheet materials.

For welding and building up (surfacing) of parts one mainly employs fusion welding. To prepare parts for welding and surfacing, the joints are imparted the required shape for ensuring a sufficient cohesion between the original metal and the overlay. The method and kind of preparation depend on the character of the wear, the material, shape and size of parts.

The edges of broken parts should be thoroughly prepared for different types of weld joints. The type of joint depends on the thickness of the part wall. When the wall thickness φ is 1.5 mm or less the edges are not bevelled, when φ is 12 mm or less V joints are used, and when φ is more than 12 mm—double V joints are used. The fracture line is followed if one has to preserve the initial dimensions of the broken pieces.

When welding thick-walled cast-iron parts, steel pins are screwed into the bevelled faces for increasing the bond between the fused metal and the parent metal. The diameter d of the pins depends on the thickness b of the part at the place of fracture: $d = (0.3...0.4)b$. The length of pin threaded part is $h = 1.5\,d$, and the distance between

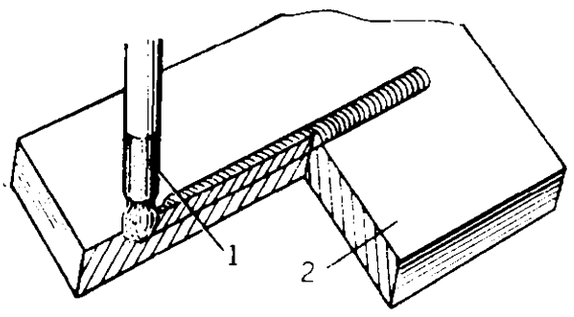


Fig. 7. Method of manual electric arc building-up

the pins (spacing) $t = (4...6)d$. The strength of the joint may be increased by using steel anchors. Drilling, threading of sockets and driving-in of pins should be done without oil, and as tight as the pins will go.

The cracks in the part should be prepared for welding, so that the electrical arc or gas flame would come in contact with the intact material. The crack running throughout the whole length of the part must be prepared for single or double V joints and drilled at the end (to avoid the increase of the crack in length on welding).

Arc welding and building-up are most widely used for restoring the parts of textile machines and equipment. Arc welding employs the heat of an electric arc to bring the metals to a molten state. Arc welding and building-up may be performed manually and automatically.

Hand welding and building-up may be carried-out by different processes: carbon-arc welding (an arc between the electrode and the work); the metal-arc welding (method of N. G. Slavyanov); and carbon-arc welding (with an arc between two electrodes).

The most largely used is metal-arc welding and building-up elaborated by Slavyanov (Fig. 7). The intense heat of the arc melts both the work *2* and the metal electrode *1*. The metal electrode is covered with a chemical coating. The burning coating forms a gaseous cloud which surrounds the arc and molten pool shielding molten metal from contamination with oxygen and nitrogen. The coating controls the chemical analysis of the weld by preventing the vapourization of essential elements in the electrode core wire such as manganese and in some electrodes serves to supply alloying elements that improve the molten weld, arc characteristics, increase welding speed, etc. The quality of weld depends considerably on the arc stability which in its turn depends on the kind of current used and the length of the arc. The stability of arc is greater at direct current than at alternating current, and for this reason with alternating current, it is necessary to employ heavily coated electrodes, and higher voltages and current frequencies.

Coating of electrodes is necessary for the following reason. If molten metal contains oxides and nitrogen in the form of iron nitrides, the mechanical properties of the metal are sharply impaired, and it becomes brittle and has low strength. The absorption of oxygen and nitrogen is stronger with the use of bare welding-wire electrodes than with coated ones. The thicker is the electrode coating, the less is the

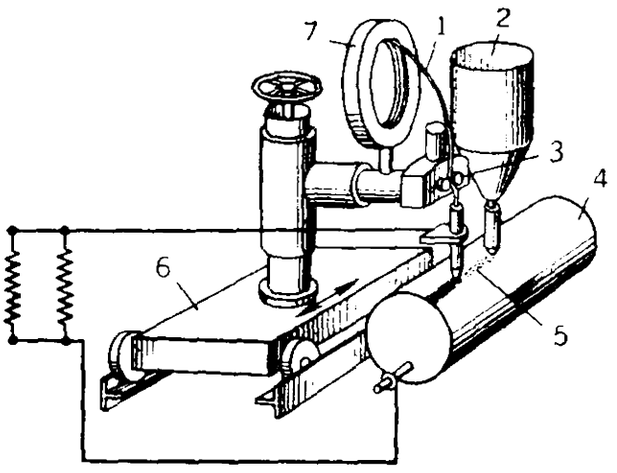


Fig. 8. Device for automatic electric arc building-up of parts

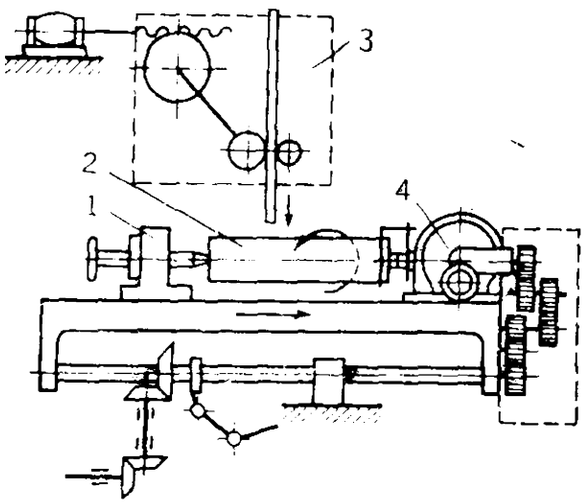


Fig. 9. Device for automatic arc building-up of cylindrical or spiral surface

content of oxide and nitrogen compounds in the molten metal.

It should also be taken in account that with welding using direct current and coated electrodes, weld metal is contaminated considerably less with oxides and nitrides than when using alternating current (all other conditions being equal). Welding repair work is usually done with a.c. welders. The use of heavily coated electrodes permits obtaining a high-quality weld-joint (not inferior to that obtained when welding with direct current). Moreover, the a.c. welding sets are more economical than d.c. welding units, as the employment of direct current necessitates the use of a generator. In this case, the current consumption is 2-3 times lower, the no-load power is 10 times less, and the cost of the set is 3-5 times lower as compared with that of the generator. The industrial area is three times less.

Automatic metal-arc welding is used for the repair of comparatively large surfaces and for series restoration of parts. It is based on the principle of using the submerged arc heat under a layer of flux (Fig. 8). An arc is created between the bare welding-wire electrode *1* and the workpiece *4* to which electric current is supplied from a welding transformer. The flux *5* is fed from the bin *2*. The electrode wire is automatically fed from the spool *7* into the arc zone by means of the welding head *3* or an automatic welding machine. In the course of hard-facing, the welding head (and consequently the arc) is displaced by means of the carriage *6* along the work with a speed equal to that of welding.

Building-up of a cylindrical or spiral surface is effected on a special unit (Fig. 9). The part *2* is fixed in a versatile milling machine between the dividing head *4* and the back stock *1*. Then, it is imparted a rotational and translational motion. The welding head *3* is firmly fixed on the machine. The automatic surfacing may also be performed on a turning lathe. In this case, the work attached in a

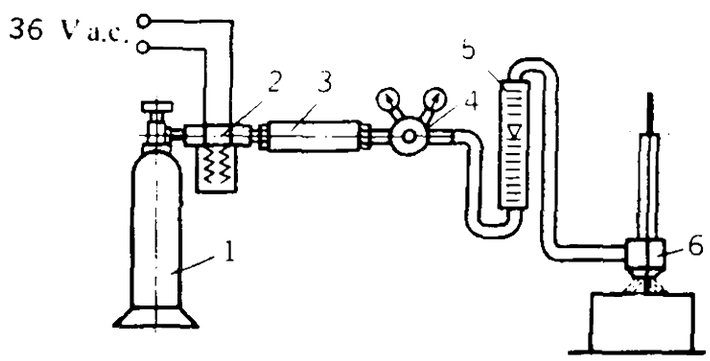


Fig. 10. Unit for building-up parts in a medium of carbon dioxide

chuck is imparted rotation, while the welding head fixed on the carriage performs a longitudinal movement.

The automatic metal-arc welding of worn-out parts under a layer of flux presents the following advantages as compared with manual building-up: higher efficiency, better quality of the overlay, lower current consumption, and better working conditions.

Gas shielded-metal-arc welding is carried out as follows. Shielding gas (carbon dioxide, argon, hydrogen, and others) is constantly fed into the zone of the electric arc burning between the work and the electrode. The shielding gas displaces the air around the arc to protect molten metal against contamination with oxygen and nitrogen. Argon is used for building-up parts of high-alloy chrome-nickel steels, copper-, aluminium- and titanium-base alloys. The highest stability of the electric arc is obtained in that shielding gas. In carbon dioxide the arc stability is somewhat lower, and in hydrogen, it is minimum. The choice of the electrode wire depends on the kind of shielding gas.

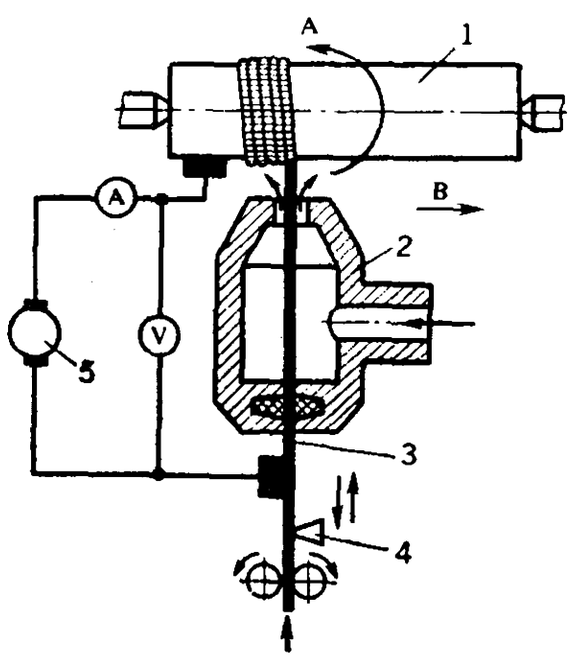


Fig. 11. Unit for short-circuited arc building-up

The gas shielded-metal-arc welder (carbon dioxide) consists of a bulb *1* (Fig. 10), heater *2*, drier *3*, step-down reducer *4*, rotameter-flowmeter *5*, and burner *6*.

Short-circuited arc building-up is a variety of metal-arc welding and is used to restore worn-out surfaces of cylindrical parts from 8 to 200 mm in diameter. Workpiece *1* (Fig. 11) and the wire electrode *3* are connected in the circuit of power source *5*. The vibrator *4* imparts longitudinal oscillations to the wire *3*, owing

to which there are periodical short-circuitings (up to 50 per second and even more) of the arc gap and the positive transfer of electrode drops into the welding bath. The vibration of the wire electrode (with an amplitude of 0.5-3 mm) ensures the alternation of electric discharges in the form of an arc, short-circuiting, and idle stroke.

The wire is passed across a short-circuited head *2*. In the course of surfacing, a cooling liquid with alkaline properties is passed through the nozzle in the head *2* into the weld zone. The emitted vapours press away the air and protect the molten metal from oxygen and nitrogen owing to which the sprayed metal acquires high mechanical properties. The workpiece to be restored is fixed in a lathe and brought in rotation (in the sense of the arrow *A*), while the short-circuited head is attached on the lathe carriage and imparted a longitudinal motion (along the arrow *B*).

Short-circuited metal-arc surfacing may be submerged (under a layer of flux or a medium of water vapour) with simultaneous cooling of the work.

Gas welding and building-up are used for restoring parts made of thin sheet steel 0.2-5 mm thick, low-melting (non-ferrous) metals and their alloys, of metals requiring gradual heating and slow cooling at welding (tool steels), and also metals requiring preheating before welding (cast iron and some grades of special steels). Moreover, this kind of repairs is used for hard facing with hard alloys and for brazing. Among combustible gases the most frequently used is acetylene which when burning in mixture with oxygen develops a temperature of 3000 to 3200°C.

At gas welding the molten metal absorbs oxygen and nitrogen from air less intensively than at electric arc welding. This is explained by the protective action of the flame and fluxes: the flame surrounding the metal melt attracts almost all the atmospheric oxygen necessary for the combustion of carbon and hydrogen.

Acetylene used for welding is obtained in acetylene generators directly at the point of welding, or brought in acetylene bottles. Usually for welding at repairs, a high-pressure portable generator is employed allowing the use of long hoses and welding burners of higher pressure and operation at low temperatures. Generators of all types have a water seal and a chemical cleaner. The water seal protects the generator from explosion because of backflash. The chemical cleaner is intended for purifying acetylene from hydrogen sulphide and hydrogen phosphate which are noxious impurities that would impair welding quality.

Oxygen is supplied to the point of welding in special seamless steel bottles provided with pressure reducers.

The main types of oxyacetylene torches are in common use today: the medium-pressure type and the low-pressure or injector type.

Moreover multi-jet oxyacetylene torches also find application in welding.

Plasma hard facing is carried out by means of plasma torches having two arcs burning simultaneously, i.e. the plasma-forming arc and the arc for melting the work metal and the overlay metal. Surfacing is applied on parts made of low-carbon or chrome-nickel steel, aluminium alloy, etc.

In *electroslag building-up* the current from the wire electrode passes to the work metal through the electroconducting liquid slag. The work to be surfaced is disposed vertically in parallel with a copper mould so that the clearance between the work surface and the mould is equal to the thickness of the built-up layer (not less than 10 mm). In this gap, a bath of liquid slag is formed in which heat is emitted. By displacing the mould gradually in vertical direction the entire gap is filled with the metal. This method is used for restoring badly worn out parts of cylindrical, conical and flat shape.

The kind of welding (arc, gas, etc.), the types of weld joints, their shape and dimensions must correspond to the technical requirements and standards. The area where metal is to be cut must be clean of all foreign matter such as moisture, rust, dirt, oil grease, and paint primer. Works made of sheet, bar, and structural rolled shapes must be checked, and if necessary straightened. Hot bending of rolled shapes (angles, rods and sheets) must be completed at a temperature not under 800°C. After heating, the work must be slowly and uniformly cooled to avoid hardening, warping, or cracking. Prior to welding, the joint edges must carefully be cleaned from dirt, rust, scale, and oil using steel brushes or other means.

In automatic submerged welding (under a layer of flux), it is necessary to clean with special care the edges to be welded as well as the adjoining metal over a width of 10-15 mm from both sides. After gas cutting, the edges of parts to be welded must be cleaned from bends of metal and adhering slag to the clean metal, and the burrs and irregularities on the joined surfaces must be eliminated. The adherence of parts must be regular over the entire length of the weld. In manual single-side butt-welding the fill on the other side of the weld must have the shape of a uniform roll throughout the whole seam length. In double-side butt welding, after the seam has been obtained, the fill on the other side of the joint must be cut away and cleaned with a steel brush. When welding with a multilayer seam, the surface of each layer must be cleaned from slag before applying the following one.

In inspecting welded structures, loaded seams must be examined with a magnifying glass over the whole weld length; and the seams which do not carry loads must be inspected over not less than 1/3 of their length. Simultaneously, the dimensions of the seam and its quality are checked by knocking with a hammer weighing 0.5-0.8 kg

and with a handle 300 mm long. The sound emitted on knocking the weld metal with a hammer must be the same, as when knocking the intact metal. When defective parts are detected—poor fusion of fill metal, cracks of any shape and delamination, porosity or slag inclusions—they are cut away and welded anew. Portions with strongly irregular seams, faults, waviness and sharply defined boundaries of scales must also be cut out and welded anew.

It is allowable to have cuttings in the work metal, which must not be more than 0.5 mm deep for metal thickness of up to 10 mm, and 1 mm deep for metal more than 10 mm thick. In case of greater depths, the work portion is cleaned and welded. Opened cavities must also be welded after preliminary cleaning.

Interior faults (interior cracks, undercuts, porosity, and poor fusion) are checked by knocking and drilling if no special tools are available. Drilling of conical recesses by means of drills, ground at an angle of 90°, is effected for opening the whole section of the seam, by cutting away the parent metal 1.5 mm from each side. After testing is completed, the drilled areas are welded.

Welded seams in containers and vessels are tested for tightness with kerosene. For this, the seam is painted from the external side with a chalk solution and after it has dried the seam is richly humidified with kerosene from the inside. In case of a defective seam dark stains appear on the surface painted with chalk. The time during which the seam has been left under the action of kerosene depends on the thickness and disposition of the seam and is about 20-40 min. The defectuous portions detected on testing are cut out and welded. Welding is preferably carried out in closed premises. When welding in open air it is necessary to provide devices protecting the welding zone from the direct action of wind, rain and snow.

3. Soldering and Application of Metal Coatings

Soldering is a method of joining metals in a preheated state by means of nonferrous alloys (solders) whose melting points are low. Unlike in welding, in soldering the parent metal is not brought into plastic state and is not melted; the melting temperature of the solder is considerably lower than that of the parent metal.

Soldering may be used to join metal parts of different shape and dimensions made of the same and different materials (steel with steel, steel with cast iron, steel with copper, etc.). Soldering is used for the repair of tin drums and cages, flyers, reeds, drums of sizing machines, etc.

Soldering may be done with soft solders (with melting temperatures of 180 to 300°C) and with hard solders (melting temperatures 620 to 870°C). Soft soldering is used in cases when soldered joints need not be exceptionally strong; and hard soldering—when solde-

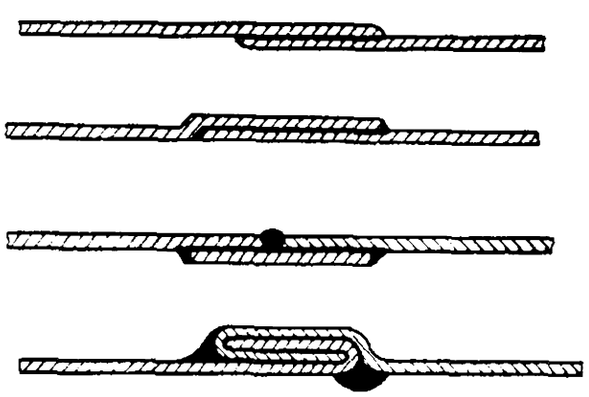


Fig. 12. Kinds of soldered joints

red joints must be sufficiently strong and fit for operating at high temperatures.

The soldering process consists of the preparation for soldering and of soldering proper. The preparation for soldering consists in grinding, washing, drying, etching, and tinning of metals to be joined. Grinding is performed with a file or scraper, and with subsequent sand papering. The soldered points are degreased by etching; oxide and slags are removed from the molten solder. Rosin and borox fluxes are most commonly used for soft and hard soldering respectively.

Soldering is preceded by etching. Alloys of lead and tin are used as soft solders. Soft soldering is carried out as follows. After grinding and etching, the copper soldering iron is heated to a temperature of 300-400°C, its heated tip is rubbed with ammonia spirit and dipped into the solder which melts and as metal drops is transferred onto the soldered work. The molten solder is evenly distributed along the seam by means of the soldering iron; the thinner is the seam, the stronger it is. Types of soldered seams are shown in Fig. 12.

For hard soldering copper-zink alloys are used. After grinding the surface or joints to be soldered, the parts with an applied solder are heated in a hearth to soften the solder. The softened solder is covered with borax without removing the part from the hearth and heating is continued until the solder melts completely. The molten solder is uniformly distributed along the seam with a steel scraper.

Soldering methods (using soft or hard solders), types of seams and their dimensions must be in conformity with the technical requirements and standards. The edges of mating parts must be carefully cleaned from rust, slag, oil, and other contamination. The solder layer must be minimum and uniformly applied on the surface of the part. After soldering the surfaces adjoining the seam are cleaned from solder.

Metal coating. The essence of metal coating is in melting of a metal wire in a special device and spraying it in automized condition under the compressed air pressure (0.5-0.7 MPa) by means of a spray gun with a speed of 140-300 m/s onto the surface to be restored. As a result, a very hard porous layer is formed on the surface of the work.

Metal coating by spraying is used for restoring the dimensions and geometrical shape of deteriorated parts as well as for obtaining antifriction coatings in bearings, for the elimination of cavities, cracks and porosity in cast iron and nonferrous castings and for protecting

parts and different structures from corrosion. Only parts which are not subjected to sharp impact loads may be metal coated (gears cannot be restored by this method). Metal coating cannot be used for building-up small surfaces which are subject to the action of high loads, as for instance shallow grooves, slots, and others.

The process of metal coating consists of two operations: preparing the surface and spraying it with metal. The preparation of surface is carried out as follows. The part is cleaned from dirt (washed in kerosene or other solvents). Cast iron parts operating with ample lubrication are heated in a hearth or with a gas burner to a temperature of 200 to 250°C for extracting the oil from the pores. When preparing parts which are bodies of revolution the irregularities of the worn-out surface (ovality, conicity, burrs, etc.) are eliminated by cutting on lathe machines. Next the surface is made rough, by cutting on it a "drunken thread", or annular grooves. Roughing of parts with hard surfaces (hardened or cement-hardened) is achieved by means of the electric sparkor short-circuiting (vibration) methods. Parts of more complicated or flat shape are shot- or sandblasted.

The prepared surface is metal coated by spraying, after which the metal layer is machined by turning, grinding, etc.

4. Repair of Parts by Electrospark Machining and Electroplating

Electrospark machining. This method is used for restoring worn-out surfaces (for instance, spindle bolsters, blades, etc.) by building them up with hard alloys and other material with the aim of strengthening rubbing surfaces; and for the extraction of broken studs, bolts and other parts.

The essence of this method comes to the following. When two metal electrodes connected to different poles of the power source (anode and cathode) are brought together, a high voltage electric field is created causing a strong electric discharge. As a result, the metal in the shape of a liquid drop is ejected from the electrode acting as an anode and is transferred to the electrode acting as a cathode. If the anode (tool) is a rod of hard alloy or of any other current conducting material, its particles which are detached on the formation of the electric spark discharge are brought on the cathode (i.e. the part to be restored) and stay fast on the surface of the work. As a result, a new layer is formed on the surface of the workpiece, the properties of this layer being dependent on the properties of the anode material. If the part to be repaired is an anode and the tool—a cathode, an aperture, a slot, or a cavity is formed in the part under the action of the electric spark discharge. The shape and dimensions of the aperture or any other depression depend on the shape and dimensions of the cathode (or the tool).

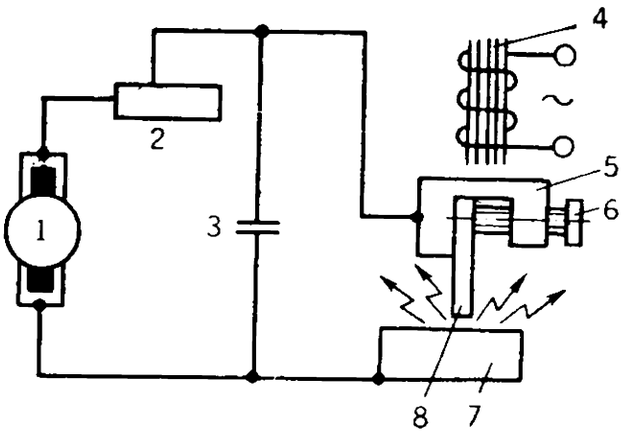


Fig. 13. Diagram of unit for electrospark building-up and hardening of parts

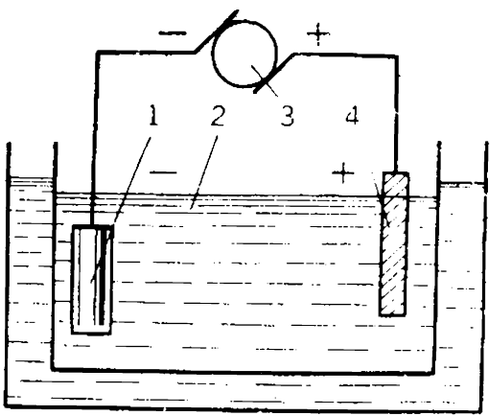


Fig. 14. Diagram of the unit for electroplating

The unit for electric spark building-up and hard facing of parts consists of a d.c. source *1* (Fig. 13), the resistance *2*, the fixed capacitor *3* and the vibrator. The metal (plate *8*) with which the part *7* is covered, is attached with the screw *6* in the vibrator holder *5*. The electromagnet *4* is engaged into the a.c. line.

Building up is effected as follows. The carefully cleaned part *7* is connected to the negative pole (cathode) after which the plate *8* attached in the vibrator is brought to the part to be restored and this plate is smoothly moved over the surface of the part by means of the vibrator.

Building up and hard facing of parts in the shape of shafts may be mechanized by fixing the part in the spindle of a turning lathe and the vibrator in the carriage.

The coating applied by the electrospark method has a great number of small pores formed as a result of current discharges. The porosity of the surface improves its wettability, i.e. the surface retains the lubricant more reliably. The applied metal layer is strongly joined with the parent metal of the part. The layer is deposited without special preparation of the part.

Electroplating. From all the available kinds of electroplating, chromium, copper, steel, or iron plating are the most largely used for the repair of parts.

The essence of electoplating comes to the following. The part *1* (Fig. 14) is placed as a cathode into the electrolyte *2* containing metal salts used for coating the part. When direct current is passed from the source *3* through the anode *4*, the metal from the electrolyte is deposited on the surface of the part to be restored.

Chromium plating is used for the restoration of spinning spindles, fluted and pressure rollers, shafts, axles, spindles and other parts with a wear not in excess of 0.1-0.2 mm per side.

The chromium plating process consists of the preparation of the deteriorated part, chromium plating proper and the machining of

the chromium plated surface. The part prepared for chromium plating must satisfy the following requirements: it must have a regular geometric shape and a high finish (8-9 class), it must be free from notches and scores, and be clean. The places on the parts which are not to be chromium plated must be insulated.

An important drawback of a smooth chromium-plated coating is its low wettability with oil. For increasing the wettability porous chromium plating is used which is effected by mechanical, chemical, or electrochemical methods.

Prior to chromium plating by the mechanical method recesses are made on the surface of the part to be restored in the shape of pores or grooves by knurling (on steel parts), or by sandblasting (on cast iron parts). Next, the cavities are coated by chromium plating.

The chemical method of chromium plating consists in short-time etching of the chromium coating in diluted hydrochloric acid (1:1). In this way, the microcracks in the chromium coating are widened and deepened.

With the electrochemical method, the chromium coating is subjected to anode pickling by reversing the polarity (the chromium plated part becomes an anode). In microcracks the chromium is dissolved, and as a result the cracks become wider and deeper.

Copper plating is used to hard face the outer surfaces of rings in antifriction bearings, various bearing linings and bushings, as well as other parts with a view to restoring the initial tightness and the worn-out helical surface of the worm gear drive, and thus obtaining smoothness of meshing and also an underlayer for chromium plating. Copper plating is used on steel, cast iron, zinc and other metals. The surface of parts for copper plating is to be prepared in the same way as for chromium plating.

Steel plating (iron plating) is used for building-up worm surfaces, restoring close fits and forming an underlayer for chromium plating. The sequence of operations in steel plating is the same as in chromium plating. After steel plating, the part is heated to a temperature of 300-400°C in order to eliminate the brittleness of the overlayer. The layer may be easily machined, and subjected to heat treatment and case hardening without cracking or flaking.

5. Glueing and Riveting

Glueing. Epoxy adhesives present the following favourable properties: a good adhesion (sticking capacity) to different materials, low shrinkage at hardening (0.15-0.14%), good hardening at a temperature of 15-100°C without application of pressure, chemical resistance in different media, waterproofness, high physical and mechanical properties in hardened state, etc. The adhesive consists of epoxy resin, a plastifier, and accumulatory and hardening agents.

The repair of parts by glueing is simple and reliable. Most various defects of flat parts may be eliminated by glueing, i.e. cracks, indentations, cuts, cavities, and pores; it is possible to restore by glueing: bushes, rings of antifriction bearings, pins, axles, holes in the bushings of sliding bearings, shafts, etc.

The surfaces of the parts to be repaired must be adequately prepared: they must be machined on a lathe, cleaned with sand paper, filed, scraped, or cleaned with a metal brush or with a jet of shot blast. The method of preparation depends on the material of the part to be repaired, its design and sizes.

The part after preparation is degreased and a layer of glue is spread over the surfaces, and using a special mandrel or a new part the

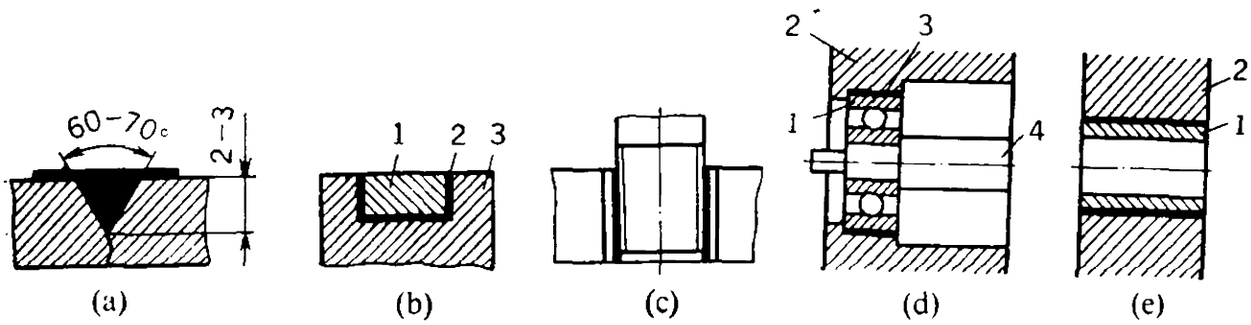


Fig. 15. Methods of part repairing by glueing

layer is calibrated before its hardening (30 min or 1 hour after its application). After calibration, the part is kept at a temperature of 20°C for 24 hours or at a temperature of 60°C for 4-5 hours until the glue becomes hard, after which the hard layer is subjected to mechanical working to obtain the required shape and size.

Let us discuss examples of repair by glueing. Conical parts are apt to develop cracks which impair the hermeticity of bodies causing oil leakage or other damages. The cracks are repaired as follows.

First, the crack is worked to a V-shaped joint (angle of opening 60-70°) to a depth of 2-3 mm; the ends of the crack are drilled with holes 2.5-3.5 mm in diameter. The surface is cleaned from both sides with sand paper or with a brush until a metal shine is obtained. The crack is prepared as said above with acetone and at the elapse of ten or fifteen minutes after the evaporation of the solvent, an epoxy glue is applied and carefully levelled with a palette knife. The crack is filled with a rope of glass fibre impregnated with epoxy resin. The rope is placed in the V-shaped joint, pressed with a smooth metal sheet and kept in this condition for 25-30 hours. After the crack has been stopped up, the glued joint (Fig. 15*a*) may be machined with any cutting tool (scraper, file, milling cutter, etc.). For planing or milling dents and scores, the defective portion of the work *3* (Fig. 15*b*) is imparted the shape of a groove in which the insert *1*

is attached with the use of glue *2*; the insert is made with adequate precision from the same material as the part to be repaired, and it should be 1-2 mm above the groove. The surfaces of the insert and of the part to be repaired are washed with a solvent and coated with a layer of glue. Next, the insert is tightly fitted to the groove and pressed with a load creating a pressure of 0.8-0.9 MPa. After the glue has hardened, the defectuous point is machined to the preset size.

Scores appearing at the wear of rubbing surfaces in the parts are worked up with epoxy glue and smoothened. The defective portion of the part is machined with an abrasive wheel or a scraper, and carefully wiped with a solvent. After the solvent has evaporated, the damaged portion is coated with a layer of epoxy glue so that it slightly protrudes above the surface of the part. After the glue has hardened this place is worked with a file, a grinding wheel, or a scraper.

For putting pins in place, the worn-out thread of the hole is cleaned with a wire brush and the pin threaded end with a flat brush, after which they are twice degreased with acetone and kept for 8-10 min at normal temperature. Next, a thin layer of epoxy glue is applied onto the thread in the hole and the pin, the pin is screwed-in as far as it will go (Fig. 15*c*) and the excess of glue which has been pressed out of the hole is eliminated. The glue is left to harden after which the joint is cleaned.

For fixing bearings in machine parts, the cavity *2* (Fig. 15*d*) of the bobbin and the exterior ring of the bearing *1* are cleaned and degreased. After the evaporation of the solvent, the surfaces of the ring and the bearing are coated with a thin layer of epoxy resin *3*, the bearing is introduced together with the shaft *4* into the cavity *2* and kept there until the glue becomes hard. Then, the glue downflows are cleaned. The bush *1* is fixed in the recess of the body *2* (Fig. 15*e*) proceeding in the same manner. To ensure a good coaxiality the two shaft bearings must be installed simultaneously.

The kind of glue and the shape of edges must correspond to the technical requirements and standards. The edges of mating parts must be carefully cleaned from rust, scale, oil, and other contaminations by means of steel brushes or other methods. The thickness of the glue layer, the number of applied layers, and the conditions under which the parts are kept after glueing depend on the type of technological machining and the kind of glue employed. The quality of glueing is checked by breaking the glued surfaces. Not less than 5% of glued parts must be subjected to testing.

Riveted joints. The holes for rivets must be carefully cleaned from burrs by counterboring and the face edge should not exceed 1.5-2 mm. Steel rivets with a diameter up to 10 mm may be set in cold condition and rivets of greater diameter only with heating. Joints which must satisfy high requirements in respect to density and when the thickness of sheets exceeds 4 mm, are to be caulked

along the joint edge and rivet heads. When the sheet thickness is less than 4 mm a good density of the joint is achieved by placing a packing band between the riveted sheets (tow or flax impregnated with red lead diluted in natural drying oil or any other composition).

The quality of riveting is determined by exterior examination, knocking and random inspection of the head size using gauges and feelers; moreover the setting of the rivet rod is also checked (filling up of the hole by the rivet body). Knocking of rivet heads with a diameter up to 19 mm is carried out with a hammer weighing 250 g, and of rivets with heads over 19 mm in diameter—with a hammer weighing 400 g. When knocking with a hammer causes the vibration or displacement of the rivet head, the rivet should be sheared and replaced with a new one. When the rivets have cracks in the head, or the head has irregular tolerances of shape, with dimensions exceeding the tolerances established by standards and norms, the rivets must be sheared and replaced with new ones. Notching of the metal by a hobby tool to a depth over 0.5 mm is not allowed. To check the degree of rod setting, it is necessary to take out 0.5% of the total number of rivets, and in case there is an incomplete filling of holes with rivets it is necessary to shear-off all the rivets which seem doubtful on head knocking.

REVIEW QUESTIONS

1. Name the different kinds of machining carried out in repair of parts.
2. What is the meaning of transfer of part sizes into repair sizes?
3. Give the meaning and make the diagrams of different kinds of part repairs with application of pressure.
4. What are the main methods of welding? Give their determination.
5. How are the parts prepared for welding and building-up?
6. What is the essence of electric arc welding and building-up?
7. What methods of building-up (surfacing) do you know?
8. What is the essence of gas welding and building-up?
9. Discuss the repair of parts by soldering.
10. What is the essence of part repair by metal coating?
11. What is electrospark machining and electroplasting?
12. What kinds of repair by glueing are known to you? Discuss them.
13. Discuss the repair of parts by means of riveted joints.

CHAPTER 3

NOTES ON MACHINE PARTS

1. Axles, Shafts and Bearings

Axles and shafts. Intended for supporting rotating parts—pulleys, blocks, gears, sprockets, rollers, etc. Though slightly differing in design, axles and shafts operate in a different manner: axles support rotating parts, and therefore they are subject to the bending load from the mass of these parts and from the loads applied to them, while shafts are members of a mechanism transmitting the torque. Depending on operational conditions, the axles may be stationary or rotating together with the parts fitted on them (car wheels, blocks), while shafts are only rotatable.

Loads taken up by shafts and axles are transmitted to the bodies or frameworks of machines through supports, i.e. bearings. Depending on the kind of friction all the bearings are classified in sliding and rolling friction plain and antifriction bearings. The parts of axles and shafts which are in direct contact with the bearings have a common name—journals (Fig. 16). The journal transmitting to the bearing the radial load and disposed at the end of the shaft is called a pin (*1*) and that disposed in the middle of the shaft is called the neck (*2*). That part of the shaft which transmits the axial load to the bearings (*3*) is called the thrust journal (*5*) while the sliding bearing taking up this axial load is called the thrust bearing (*4*).

Axles are always straight while shafts may be straight, cranked, and flexible. Mostly, straight shafts are used. As classified by their design the shafts and axles may be smooth, stepped, solid, and hollow. For mounting gears, pulleys, couplings and bearings on the shafts and axles, adequate cylindrical or bevel mountings are provided with certain diameters and lengths. To fix these parts in axial direction the shafts are equipped with shoulders and

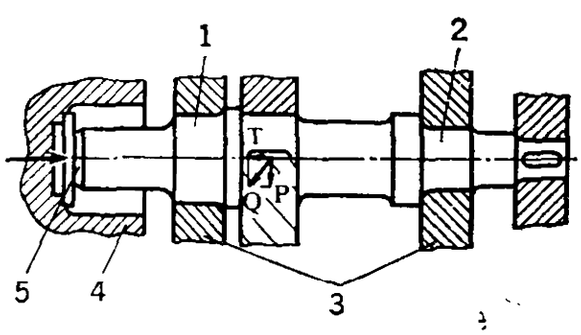


Fig. 16. Journal

threading for fixing the parts with a nut, etc. For transmitting the torque to the shafts keyed, splined and pinned joints are used. Mostly solid shafts and axles are used, but in the case when the mass of parts must be reduced or it is necessary to pass the shaft through another part, as for instance a tie rod, the shafts and axles are made hollow.

Axle and shaft bearings. Bearings may be classified according to the following features. For instance, depending on the kind of friction they may be classified into sliding or plain bearings in which the supporting part of the axle or shaft (journal, pin, neck, heel) slides on the interior surface of the bearing and into rolling or antifriction bearings in which the sliding friction is replaced by the rolling friction (this being achieved by the introduction of rollers or balls between the journal and the bushing). Depending on the direction of the load applied the bearings are subdivided into radial bearings taking up radial loads, thrust bearings taking up axial loads, and radial thrust bearings taking up radial and axial loads.

Sliding or plain bearings. The advantages presented by these bearings are: smaller dimensions as compared with the rolling antifriction bearings; the use of split bearings which may be mounted on the main journal of crankshafts; the operation with shafts rotating at a speed of 10 000 min^{-1} and higher; possible operation in water and other aggressive mediums under vibration and impact loads; the possibility of using large-size journals.

The drawbacks of sliding bearings are the need of constant observation and continuous oiling, the reduced efficiency, the nonuniform wear of bearings and journals, the use of costly nonferrous metals and alloys (bronze, babbitt), and relatively long journals and linings.

The friction determines the wear and heating of the bearing and its efficiency. To reduce friction the bearings are lubricated with special lubricants. Depending on the bearing working conditions the friction may be classified into dry, semidry, semifluid, and fluid friction.

In the absence of lubricant between rubbing surfaces, a *dry* friction is created. In this case, there is an intensive wear and jamming of rubbing surfaces, the friction coefficient being $f = 0.1$ ....0.3. In case of *semidry* friction the lubricant is supplied irregularly and in an insufficient amount to the rubbing surfaces. When this kind of friction occurs, the surfaces of the pin and bearing come in contact which results in their wear, the friction coefficient being $f = 0.1$ . . . . . 0.25. If the layer of lubricant between the rubbing surfaces is very thin and is easily impaired by the surface roughness a *semifluid* friction is created. When the oil film is ruptured, the metal rubbing surfaces come directly in contact with each other which causes their wear, and the friction coefficient in this case is $f = 0.005$ . . . 0.1.

When the oil layer between the rubbing surfaces is sufficient (2-70 μm) so that their contact is avoided a *fluid* friction is created. One part of the lubricant layer adheres to the pin surface and the other to the bearing surface; with friction occurring between these layers the part wear is almost completely obviated; $f = 0.001 \ldots 0.005$.

The aim of bearing lubrication is to reduce losses on friction, to reduce or obviate wear, to eliminate heat formed at rubbing, to protect the bearings from corrosion, to lessen noise, and to provide a better sealing by filling the gaps with grease between the rotating and stationary surfaces. All the lubricants are subdivided into liquid oils, consistent, and solid grease.

Liquid oils are the most largely used lubricants. As a rule, for oiling the machines petroleum oils find application. The most important characteristic of the oils is their viscosity. The *viscosity* or internal friction is the resistance against the shifting of one lubricant layer relative to the other. Viscosity may be dynamic or absolute and kinematic. Dynamic viscosity is determined by the hydrodynamic calculations of a given lubricant. Kinematic viscosity is determined by the time necessary for the flow of a preset amount of oil through a capillary tube under the action of gravity. The unit of kinematic viscosity is stokes (the name of the English scientist Stokes). The list of the main liquid oils used in machine-building is given below:

Oils	Kinematic viscosity, cSt*
Light industrial oils (at a temperature of 50°C)	
for high-speed mechanisms (winter-type)	4-5.1
for high-speed mechanisms (summer-type)	5.1-8.5
separator oil	6.1-10
Medium industrial oils (at a temperature of 50°C)	
industrial oil 12	10-14
separator oil	14-17
industrial oil 20	17-23
30	27-33
45	38-52
50	42-58
Turbine oil (at a temperature of 50°C)	
turbine oil 22	20-23
30	28-32
46	44-48
57	55-59
Heavy industrial oil (at a temperature of 100°C)	
cylinder oil 11	9-13
cylinder oil 24	20-28
for presses	over 10
for rolling mills П-28	26-30

* Centistoke (1 cSt = 10^{-2} Stokes)

Liquid oils may be used for high-speed shafts and axles at low and high temperatures; they have a low internal friction, ensure good heat elimination, and if necessary can be changed without disassembling the unit. These oils are disadvantageous in that they require frequent replenishing and the use of packings of more intricate shape to prevent the leak.

Greases are obtained by adding thickening agents such as calcium and sodium oils into liquid oil. The most largely used greases on a calcium base are the cup greases and on a sodium base—constalines.

Greases are employed with high loads and small rotational speeds of shafts and axles. Greases are entirely leakless (it is enough to use simple packings), completely fill the clearances between the rotating and stationary parts, may operate during a long period of time (a year and more without change) and reliably protect the parts against corrosion. Greases present the following disadvantages: they are sensitive to changes in temperature, present a high internal friction and are difficult to replace. Usually greases are packed at the assembly of a unit and are periodically replenished by means of special cup oilers or a grease gun through grease cups.

When usual lubricants cannot ensure normal operating conditions for the parts and units, solid lubricants are used. Most largely employed is graphite grease which is a mixture of graphite powder with consistent grease or as a suspension in liquid oil. Such greases are used in heavily loaded bearings with a low sliding speed and high temperatures. Molybdenum disulphide ameliorates the antifriction properties of the metal. It is applied as a powder or paste on the metal surface rubbed in with soft material and polished. The formed film is not ruptured in an aggressive medium, sustains high loads and may operate at temperatures from —70 to +300°C.

Antifriction bearings are largely used in the industry including textile machinery. The main advantages of antifriction bearings in contrast to sliding bearings are the low friction coefficient, a higher load carrying capacity with a smaller width of the bearing, a lower consumption of lubricants, the ease of erection, maintenance and servicing, interchangeability, and the possibility of mass production of standard bearings which considerably reduces their cost. The main disadvantages of antifriction bearings are a limited ability of taking-up impact loads, different life at equal rotational speed and load, and big exterior diameter of bearings as compared with plain bearings.

Usually the antifriction bearing consists of the balls and rollers, the outer and inner rings and separators. Used sometimes are bearings without outer or inner rings. In this case the functions of the ring are performed by adequate parts of the shaft and body. In some cases use is made of bearings having no rings, with balls fixed

in a retainer. In needle bearings there are no separators and the races are completely filled with balls or rollers.

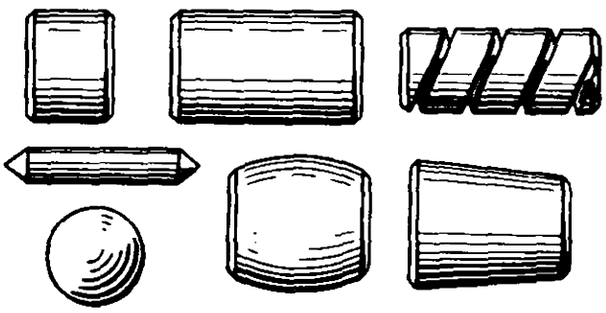


Fig. 17. Kinds of rollers

Antifriction bearings are classified as follows:

according to the shape of rolling solids—balls and rollers. The rollers may be cylindrical and short, cylindrical and long, helical, needle, barrel-shaped and conical (Fig. 17);

according to the direction of the applied load—radial, thrust, and radial thrust bearings. Radial bearings take up the radial load which is perpendicular to the geometrical axis of the shaft (simultaneously they may take-up only an inconsiderable axial load); thrust bearings take up the axial load applied along the rotational axis, and radial and thrust bearings—a combined load, i.e. simultaneously the radial and axial loads;

according to the number of ball or roller rows—single-row, double-row and four-row bearings;

according to the method of shaft misalignment compensation—self-aligning (with a spherical interior surface of outer rings in radial bearings) and non-selfadjusting;

according to overall dimensions with the same inner diameter—extra-light and superlight, light, medium and heavy bearings;

according to the width—narrow, normal, wide, and superwide;

according to the precision of execution—standard class, higher class, high class, extra-high class, and super-high class.

The life of antifriction bearings highly depends on their proper mounting and disassembling. The bearing is mounted on the shaft with an interference fit by pressing the inner ring by a hand press or by heating the bearing in oil at a temperature of 80-100°C. On heating the bearing hole increases and it can be freely fitted on the shaft. For removing the bearing from the shaft or body special removers or pullers are used. Prior to the erection, all the mounting sets should be carefully cleaned and the bearing washed in gasoline. When mounting or dismounting an antifriction bearing the force should be applied only to the ring which is being or was mounted. It is not allowable to apply force through the balls and rollers, as indents will appear on their surfaces or on the races, and the bearing will be ruined.

2. Clutches, Couplings and Springs

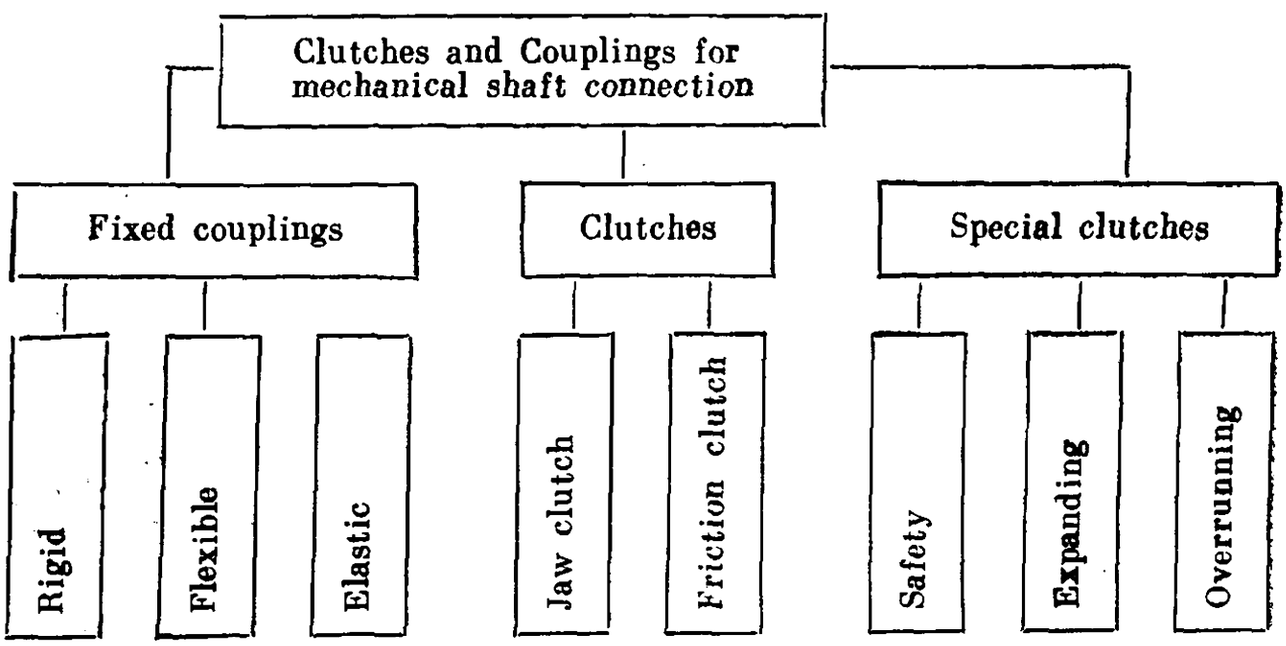
COUPLINGS are used for transmitting rotation from one shaft to another disposed on the same centre line with the first one, for dam-

ping impact loads, connecting and separating shafts during machine operation and also for transmitting rotation only in one direction or at a preset rotational speed, etc. Couplings may be subdivided into three groups: rigid, flexible, and elastic.

Rigid couplings are used in cases when a built-up shaft must operate as a whole one. Such couplings require a precise coincidence of connected shafts as the non-axiality appearing in the course of operation may cause bending and damaging of bearings. The simplest rigid coupling is a sleeve mounted with an interference fit on the ends of the shafts. The torque is transmitted by means of semi-circular or sunk keys. This kind of coupling is called an end sleeve. Wide application find flange couplings consisting of two flanged half-couplings keyed on the ends of the shafts.

Flexible couplings are used to compensate the misalignment of shafts. To such pertain jaw extension couplings which compensate only the longitudinal displacement of shafts. The double slider coupling compensates for the radial (within 0.04 shaft diameter) and an inconsiderable angular (not more than 30′) displacement of shafts. The couplings are used at low rotation speeds—under 250 min^{-1} and with small diameters of connected shafts—under 100 mm). A tooth-type coupling compensates different shafts for misalignments (longitudinal, radial—within 1-8 mm, and angular $-\alpha \leqslant 1°$).

Classification of Clutches and Couplings



Elastic couplings not only compensate for the shaft misalignment, but also ensure dampening of jerks and impacts by the deformation of the elastic elements. There are couplings with nonmetallic elastic elements (rubber and leather) and metal flexible elements (steel spring). For instance elastic couplings with rubber bushed studs may compensate for a radial misalignment of $\delta \approx 0.3\text{-}0.6$ mm, an-

gular misalignment $\alpha < 1°$, and an inconsiderable axial displacement of shafts. These couplings are used for connecting shafts with a diameter of 16-150 mm. The deformation of elastic elements dampens jerks and impacts, but the damping capacity of the coupling is inconsiderable.

Clutches ensure the connection and disconnection of two shafts in the course of machine operation without its stoppage and dismantling. There are two kinds of clutches: jaw and friction clutches.

Jaw clutches consist of two half-couplings, the left half-coupling being attached on the shaft by means of a sunk key with an interference fit, while the right-hand one is fitted on the driven shaft by virtue of a sunk key and with a slide fit so that it may be displaced along the shaft axis by a forked shifter. On the faces of both half-couplings there are provided protrusions (cams) and recesses. The cam profile may be rectangular or trapezoidal (which facilitates coupling engagement and allows the reverse motion without jolts). The use of jaw clutches is recommended when the shafts to be connected rotate at relatively slow speeds.

Friction clutches ensure a smooth impactless engagement owing to the slippage of the half-coupling rubbing surfaces. Depending on the shape of their working surfaces, friction clutches may be subdivided into disk clutches (flat surface), cone clutches (conical surface), shoe, band and other types of clutches (cylindrical surface). Both the friction and jaw clutches are used to prevent shaft misalignment.

Special clutches are designed to protect the drive from overloads (breakages) and to transmit the torque only in one direction or at the preset rotational speed. There are different types of special clutches, i.e. safety, centrifugal, and overrunning clutches, etc.

Safety clutches with a shearing pin consists of two half-couplings keyed to shafts with interference fit. The torque is transmitted through the pin which is sheared at overloads.

Centrifugal clutches automatically connect the shafts only when the preset rotational speed is exceeded. Such clutches are used for the automatic engagement and disengagement of mechanisms at a certain rotational speed of shafts with great mass, and for obtaining a smoother start.

The overrunning clutch transmits the torque only in one direction and allows free relative rotations in the reverse direction.

SPRINGS. These are elastic elements which are used for tensioning or pressing couplings, brakes, and friction drives, for accumulating energy with its subsequent use (impact mechanisms, dampers and others), for the return of valves and cam mechanisms, and for measuring the efforts in dynamometers, and other instruments.

Depending on the load applied, the springs are subdivided into extension, compression, torsion, and bending springs; and accor-

ding to their design into coil, cylindrical and shaped, disk, sheet, flat, spiral etc. Most largely used in machines are coiled cylindrical extension and compression springs made of round wire.

3. Transmissions

Devices for transmitting power from the motor to the executive mechanism are called *transmissions.* Transmissions between the motor and executive mechanisms are used to change and adjust the rotational speed, to transform rotational movement into translatory; and to increase the torque, etc. Mechanical, pneumatic and hydraulic transmissions have found wide application in textile machinery building.

The main kind of transmissions are mechanical drives, that may be classified as follows:

according to the principle of operation—friction, belt, toothed, worm, screw, and chain drives;

according to the kind of rotational feed changing*—step down (reducers) and step-up transmissions (multipliers);

according to the mutual disposition in space—those placed between parallel, intersecting and crossing shafts;

according to the kind of shaft motion—ordinary (the shafts rotate around their axis) and planetary (the shafts with the parts mounted on them move in space around stationary axles as planets move around the sun);

according to the number of separate transmissions taking part simultaneously in a given drive—one and multi-step (two, three- etc. stop);

according to the design—open transmissions, having no cases to cover them; half-closed—mounted in the same way as the open transmissions, but provided with a light protection housing; closed and housed in a common strong and rigid case which also encloses the bearings (closed transmissions are used for heavily loaded high-speed drives).

Friction transmissions are subdivided into two groups: one with a constant and the other with an adjustable gear ratio. The first group of transmissions is employed for mechanisms requiring smooth motion, noiseless operation, impactless engagement in running, etc. The second group of transmissions relates to variable-speed drives ensuring a smooth and stepless change of the gear ratio within certain limits. Friction drives present the following advantages: simplicity of design, absence of impacts, smooth and noiseless ope-

* Depending on the kind of transmission the ratio of the angular speed or the rotational speed of the driving (input) and driven (output) shafts may be constant, or may change within certain limits according to the stepped (gear box) or smooth stepless (variable speed drives) law.

ration, the most precise gear ratio instant value, the possibility of smooth stepless change of gear ratio and the protection against breakages in case of casual overload due to the slippage of rollers.

The drawbacks of friction transmissions are: a limited power transmission (up to 10 kV), a heavy load on the shafts and their bearings due to the compression forces of rollers, the strong wear of rollers being the cause of noises in operation and the comparatively low efficiency ($\eta = 0.7$-0.92).

Friction drives cannot ensure a rigid kinematic connection. The friction drive rollers are made of materials capable of ensuring a good surface and wear resistance, and also a greater friction factor. For operating without lubrication use is made of hardened steel rollers. It is observed that in friction transmssiions, there occurs a fatigue flaking of the roller working surfaces (when working with lubrication), wear (when working without lubrication), and scoring of the surface (when operating at high speeds and loads).

Belt drives are a veriety of friction transmissions by a flexible connection, i.e. belting. Depending on the shape of the belt cross section the drives may be of the flat-belt, V-belt, and round-belt type. The advantages presented by the belt drive are the possibility of power transmission over long distances (up to 15 m and more), smooth and noiseless operation, the absence of sharp deviations in loads owing to flexible stretching of the belt, protection of mechanisms from overloads owing to the possible belt slippage, simplicity of design and the ease of operation, and the possibility of different arrangement of shafts in space. The drawbacks of belt drives are their large sizes, the inconstancy of the gear ratio due to belt slippage, the high load on the shafts and bearings which is necessary to ensure the preliminary tension of the belt and the short life of belts (1000-5000 h).

The belts must have a high traction ability, i.e. high cohesion with the pulley surface without slippage; high resistance, long life and wear resistance, as well as low elasticity at bending; moreover they must have a low cost.

Depending on operation conditions, driving belts may be made of different materials, such as leather, rubberized cotton, and wool. Endless standard belts are used for high-speed drives which considerably enhances the quality of transmission, but their application is limited due to the complexity of their manufacturing. V-belts have a trapezoidal shape in cross section and are made of rubberized textile cord. The belt pulley consists of the rim carrying the belt, the hub keyed on the shaft, and the spokes or the disk connecting the rim with the hub. The shape of the rim working surface is determined by the kind of belt to be used.

Depending on the linear feed, the pulleys are made of gray cast iron (at $v \leqslant 30$ m s^{-1}) of a steel casting (at $v = 30$-45 m s^{-1}) and of alloyed steel or duralumin (at $v > 45$ m s^{-1}).

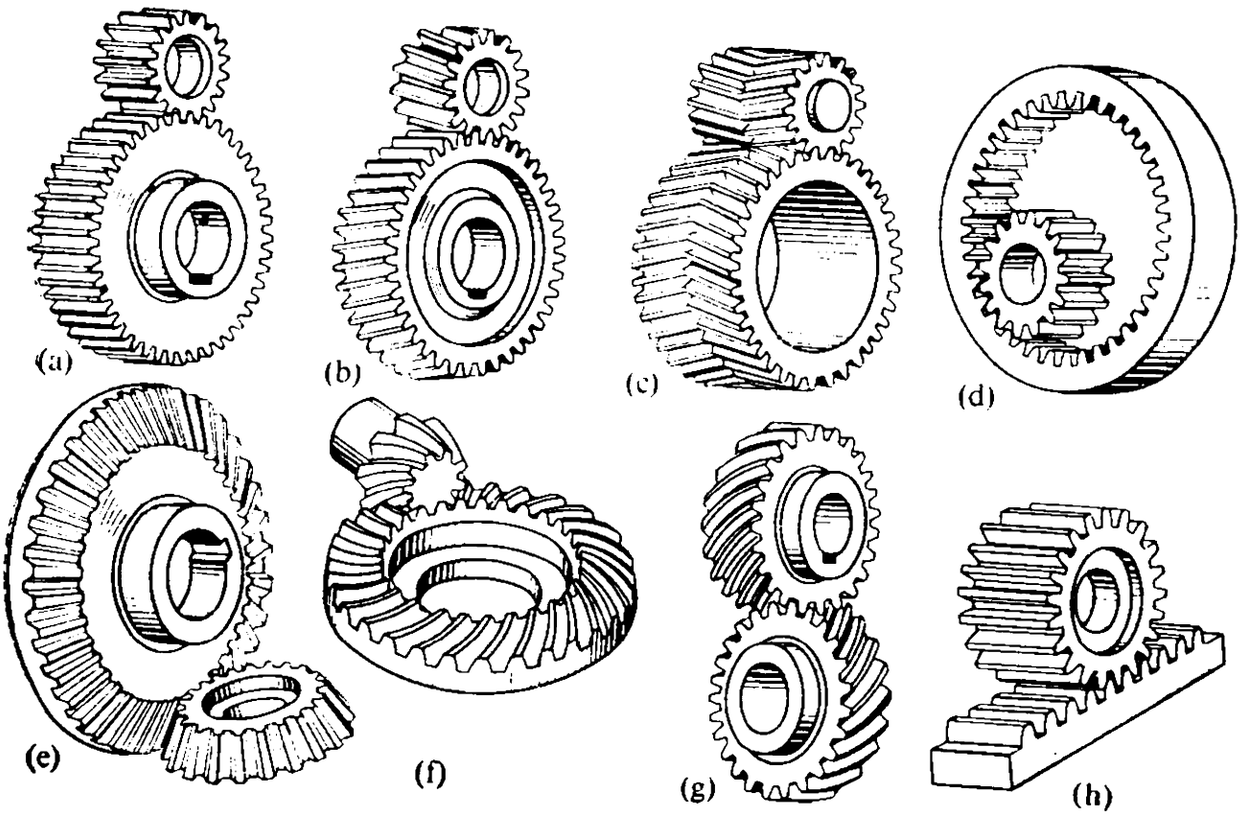


Fig. 18. Kinds of gearings

The pulleys used for V-belts operating at a speed of $v \leqslant 25$ m s^{-1} are usually made of gray cast iron or aluminium alloys.

Gear transmissions. Consist of two meshing gears—a small and a big one. Gearings are classified according to:

the shape of the tooth profile—involute and cycloidal gearing (used in watch mechanisms);

the mutual disposition of the driving and driven shaft axes—with cylindrical gears and shaft axes disposed in parallel (Fig. 18*a-d*), with conical gears and intersecting shaft axes (Fig. 18*e*, *f*), with screw gears and crossing shaft axes (Fig. 18*g*), with gear and rack for transforming the rotational motion in translation, and vice versa (Fig. 18*h*);

the relative rotation of gears and teeth disposition—with external gearing (the gears rotate in the opposite directions), and with internal gearing (the gears rotate in the same direction, see Fig. 18*d*);

the disposition of teeth in relation to the gear generatrix—spur gearing (see Fig. 18*a*, *d*, *e*, *h*), helical gearing (see Fig. 18*b*), herringbone gearing (Fig. 18*c*), and curvilinear gearing (Fig. 18*f*);

the operation conditions and design—open (not enclosed in a housing, working without lubricant or with periodical lubrication and not protected against dust and dirt), closed (enclosed in a special housing protecting them against the penetration of dust and dirt and working with constant ample lubrication), and half-closed (protected against free penetration of dust and dirt by means of a thin protection hood);

the linear speed—slow speed ($v \leqslant 3$ m s^{-1}), average speed ($v = 3 \ldots 15$ m s^{-1}) and high-speed ($v > 15$ m s^{-1}).

The advantages of gear transmissions are a constant gear ratio, high efficiency (up to 0.99), rugged design, the ease of service, and an unlimited range of transmitted power (from hundred fractions of a kilowatt to tens of thousands of kW). The drawbacks of gear transmissions are their comparatively complicated manufacture requiring special precise equipment and tools, and noisiness at high speeds.

Depending on their use, the gears are manufactured by different methods. For instance, for low-speed drives gears with cast teeth are employed. The precision of their manufacture is not high, but owing to the hard crust on the tooth surface its wear resistance is high. To improve the precision of gearing, the gears with cast teeth are sometimes subjected to additional mechanical treatment. At present, in mass production hot gear generation is used without further machining.

As a rule the manufacture of gears consists of the following operations: the production of a blank (by casting, forging, or stamping) with further turning on a lathe; gear teeth cutting on milling machines, gear shapers, or other special machine tools; heat treatment (if such is needed); teeth finishing (by grinding, shaving, or lapping) for gears of not under the 7th class of precision.

Gear teeth cutting may be carried out by the template or by the generating methods. According to the first method the cavity between the teeth is cut on a milling machine by a special single-angle gear tooth cutter (Fig. 19*a*) or by a side mill (Fig. 19*b*) after which the blank is turned to one tooth and the operation is repeated. The precision of this method of cutting is not high as the cutter profile may be distorted, the work and tool may be inaccurately mounted, or the divider has not been set precisely. Therefore such gears are used for slow and average speed transmissions. According to the second method of gear cutting or generating the cutting tool, gear shaping cutter (Fig. 19*c*), the rack-type gear cutter (Fig. 19*d*), or the gear hob are generated in the process of gear cutting together with the gear blank as a couple of gears which ensures a higher precision of meshing than the template method. For this reason, the gears are mainly manufactured by the generating method.

The serviceability of the tooth is mainly affected by contact stresses applied for a short moment of contact at a given point and bending stresses acting during the whole time the given tooth is engaged. These variable stresses cause the wear destruction of teeth—breakage from the bending stresses and surface flaking from the action of contact stresses. Let us discuss the most characteristic kinds of teeth deterioration.

Teeth breakage may be caused by heavy overloads and fatigue of the metal under the action of variable stresses. Sometimes, tooth

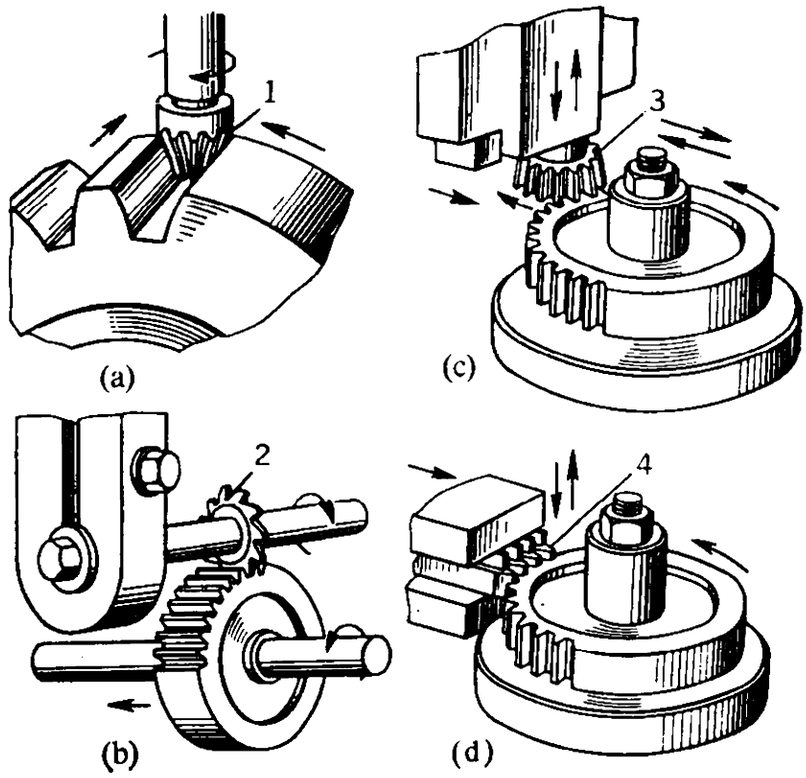


Fig. 19. Methods of gear generation

breakage is caused by shaft misalignment and a nonuniform loading in tooth length (Fig. 20*a*). The measures to avoid teeth breakage are: the increase of the module, a modification of meshing, heat treatment and the reduction of stress concentration.

The main kind of teeth surface destruction in closed transmissions with proper lubrication is the fatigue flaking or spalling (Fig. 20*b*). Though there is no metal contact of teeth in such transmissions, but in the course of a lengthy operation there appears fatigue of the surface layer. Big recesses appear on the surface which continue to develop into cavities followed by flaking and deterioration of the oil film which result in an intensive destruction of the tooth surface. When the teeth are not very hard, favourable results may also be

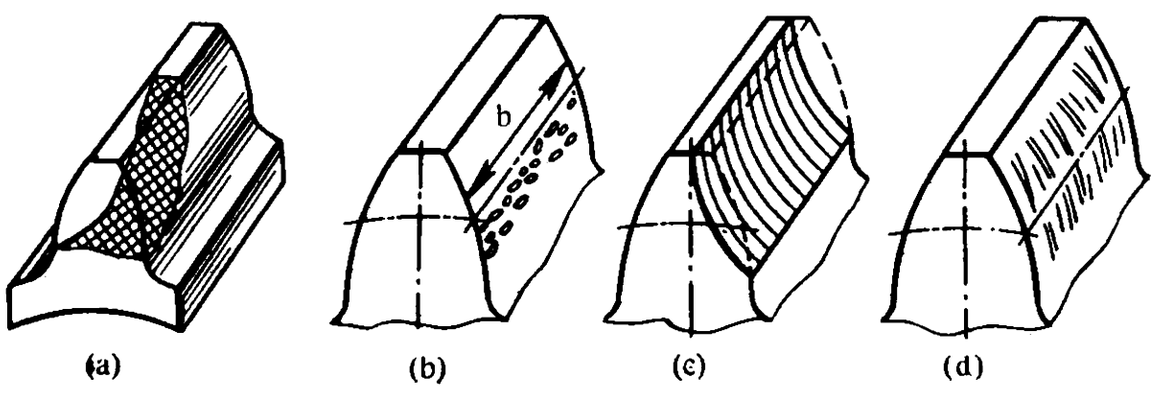


Fig. 20. Kinds of teeth wear

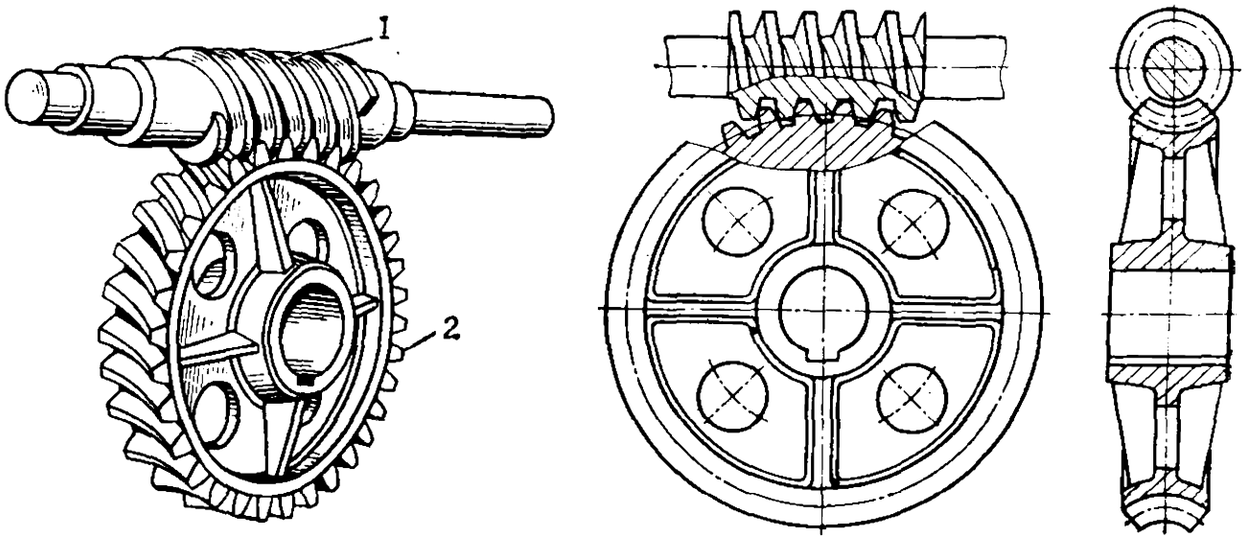


Fig. 21. Worm gearings

obtained, such as better running-in of teeth surfaces and smoothening of cavities. Flaking may be avoided by increasing the tooth surface hardness through the application of heat treatment and obtaining a higher precision of execution, etc.

Abrasive wear (Fig. 20*c*) is the most largely encountered kind of open gear deterioration because of poor lubrication (dirt and abrasive particles get into the gearing); in this case the surface is worn out, the tooth thickness is reduced, the clearances in the gearing are increased, and noisy running develops (knocks). All this can lead to teeth breakage. To avoid wear, it is necessary to increase the hardness, to improve the finish of the teeth surface, and to protect them from contamination.

Jamming (Fig. 20*d*) is observed in high-speed and heavily loaded transmissions. At the point of contact under the action of high pressure and temperature, oil is squeezed out and metal particles as if become welded and torn off from one of the surfaces. The build-up is formed which scratches the working surfaces. A special oil is used to reduce jamming.

Plastic shearing of the teeth surface layer is characteristic for heavily loaded slow speed transmissions with gearings made of materials of low hardness. To avoid this, it is necessary to increase the hardness of the teeth material. In such gearings it is observed that the surface layer obtained by nitriding, cyaniding, and cementation would peel off as a result of high contact stresses. Peeling is very dangerous as bits of metal getting between the teeth rapidly bring the whole gear transmission out of order.

Worm gearings serve for transmitting the motion between two nonparallel but nonintersecting shafts. In that transmission the motion is effected on the principle of a wormgear, with a worm having trapezoidal threading *1* which comes in engagement with a gear having spiral level teeth *2* (Fig. 21).

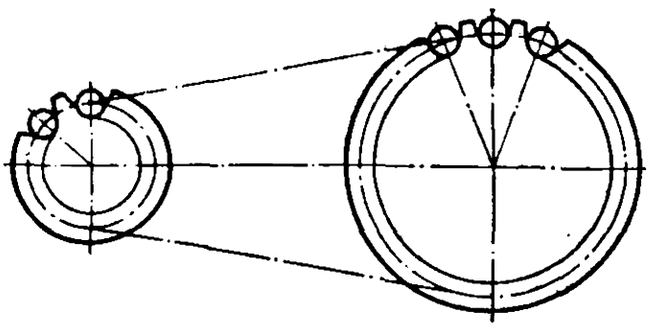


Fig. 22. Diagram of chain drive

Worm gearings are largely used in textile machine building owing to the possibility of obtaining high gear ratio* in one couple (10-80 for power transmissions and up to 500 for dividers), smoothness of meshing and noiseless operation, the possibility of self-braking, comparatively small overall dimensions and mass. Worm gearings present disadvantages, such as comparatively low efficiency, strong heating at lengthy operation, high cost of the material (bronze) used for the worm gear, and the passibility of transmitting power only up to 60 kW.

Considering the hard working conditions the materials for the worm gear must have good antifriction properties, high wear resistance and a low jamming ability. In modern transmissions the worms are made of carbon and alloy steel. In heavily loaded transmissions the worm is subjected to heat treatment (cementation, hardening, etc.) with subsequent grinding or polishing. The worm gears are mainly made of bronze, and for minor slow-speed gearing cast iron is employed. Tin bronze is considered as the best material for worm gears. They are used for manufacturing heavily loaded gearings operating at high sliding speeds (up to 25 m/s). Tinless bronze is used for gearings operating at sliding speeds up to 10 m/s and cast iron for speeds up to 2 m/s.

Chain drives are largely used in textile machinery mainly as a stepdown transmission. Their main advantages are: the possibility of using smaller overall dimensions than in belt drives at considerable interaxial distances (up to 8 m), constant gear ratio (i_{max} = = 8), high efficiency (up to 0.98), unlike in belt drives, lower loads on the shafts, and the possibility of imparting rotation to several shafts by one chain. The drawbacks presented by the chain drives are chain stretching due to wear in articulations, the high cost of the chain, the impossibility of reversing without stopping the machine, loud noise during operation and the necessity of a careful maintenance (adjustment, lubrication, and elimination of misalignment).

The chain drive consists of two sprockets (the smaller driving sprocket and the greater driven sprocket) keyed onto shafts (Fig. 22). The sprockets are connected by an endless chain. In mechanical

* The gear ratio of a worm gear is the ratio of the number of the worm teeth to the number of worm threads.

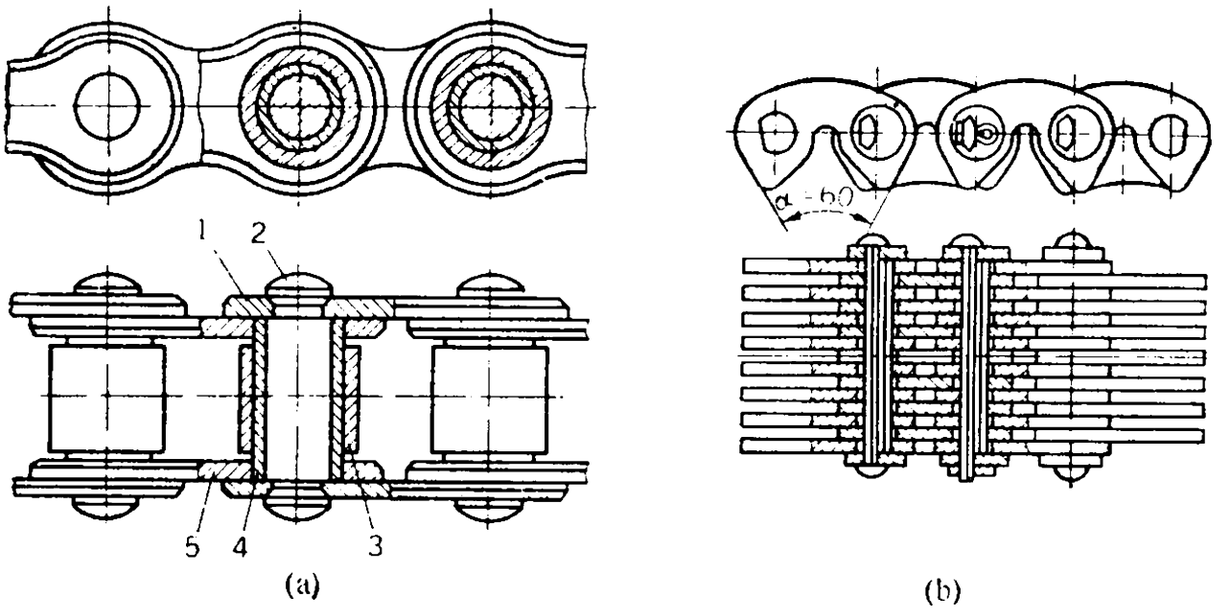


Fig. 23. Chains
(*a*) roller chains; (*b*) toothed

drives chains of different design are used, i.e. at speeds up to 15 m/s—roller chains with 1-4 rows, and at speeds from 20 to 25 m/s—noiseless toothed chains.

Roller chains (Fig. 23*a*) consist of exterior movable links *1* and interior links *5*. The interior links are force fitted on the ends of the bushings *4* and the exterior links—on the shaft *2* having its ends riveted over. The bushing *4* and shaft *2* form a hinge. For reducing the wear, rollers *3* are fitted on the bushing. Toothed chains (Fig. 23*b*) consists of a set of toothed plates and hinges. The working surfaces of the teeth are limited by surfaces at an angle of $\alpha = 60°$. The material used for the chain parts must be highly wear-resistant and strong. The plates are made of plain and chrome plated steel while the shafts, bushings and rollers—of carburized steels with further hardening.

Gear boxes (reducers) are mechanisms composed of toothed or worm gearings enclosed in separate housings and working in an oil bath. The reducing gear box is intended for decreasing the shaft rotational speed and consequently for increasing the torque. Mechanisms designed for increasing the shaft rotational speed and made as a separate unit are called multipliers.

The reducers are classified according to the following characteristics: by the type of the drive—into toothed, worm, and toothed-worm reducers; according to the number of steps—into one-step reducer (when the transmission is effected by one couple of gears), two-, three- and multistep reducers; according to the type of gears—into cylindrical (with straight or skew tooth), conical (with straight or curvilinear tooth), conical-cylindrical and so on; and according to the disposition of the reducer shafts in space the reducers are subdivided into horizontal, vertical and inclined reducers.

REVIEW QUESTIONS

1. Give the characteristics of axles and shafts. What features have they in common and what are different?
2. What kinds of bearings are used for axles and shafts? Give their classification.
3. Discuss sliding (plain) bearings: their advantages and drawbacks.
4. What kinds of friction do you know?
5. How are lubricants classified?
6. Discuss antifriction bearings: their advantages and disadvantages. How are they classified?
7. What do couplings and springs serve for?
8. What are transmissions, and what kinds of transmissions do you know?
9. Discuss friction drives: their advantages and disadvantages.
10. Discuss belt transmissions: their advantages and disadvantages.
11. Discuss gear transmission, give their characteristics and classification.
12. What methods of gear cutting do you know? What are the main kinds of teeth wear and their causes?
13. Discuss worm gearings: their advantages and drawbacks.
14. What kinds of chain drives and reducers do you know?

CHAPTER 4

REPAIR OF GENERAL PURPOSE PARTS AND ASSEMBLY UNITS

1. Acceptance of Machines for Repair and Their Disassembly

Acceptance of machines for repair. All the machines and looms are accepted for the following major overhaul or medium repair in strict conformity with the adopted schedule. If the machine or loom is to be subject to *medium repair*, the shop foreman makes out a list of defects not later than five days before the repair term. This is done to determine the amount of parts and materials necessary to have at hand for carrying-out the repair. If the machine or loom has been accepted for *major overhaul* the list of defects is written by the personnel of the mechanical repair department during the last medium repair. The list is specified and checked ten days before the beginning of the major overhaul. It should contain: the enumeration of mechanisms and units to be repaired; parts to be replaced or restored; and assessment of operational capability of the machine.

The machine received for scheduled repairs must contain all the parts and mechanisms, as otherwise the machine is not accepted for repair. The list of defects is specified in the course of repairs. The assistant foreman and the worker attending to the machine take part in compiling the list of defects.

Disassembling the machine into units. Disassembling is carried-out in reverse order as compared to the assembly, i.e. parts which are the last ones to be assembled are the first to be removed. Depending on the kind of the repair to be carried out, the disassembly may be complete (major overhaul) or partial (medium repairs). First, the machine is dismantled into assembly units and next the latter are disassembled into parts. Sometimes in addition to units, large assemblies, such as loom dobbies, are removed from the machine. In the course of machine repair different kinds of work are carried out: nuts, bolts, pins and screws are screwed-in and out; bushes, bearings and axles are unpressed and pressed again; pulleys, gears and cams are removed and fitted in place. Different kinds of tools and devices are used for these operations (mallets, hammers, wrenches, drifts, screwdrivers, strippers, presses, etc.).

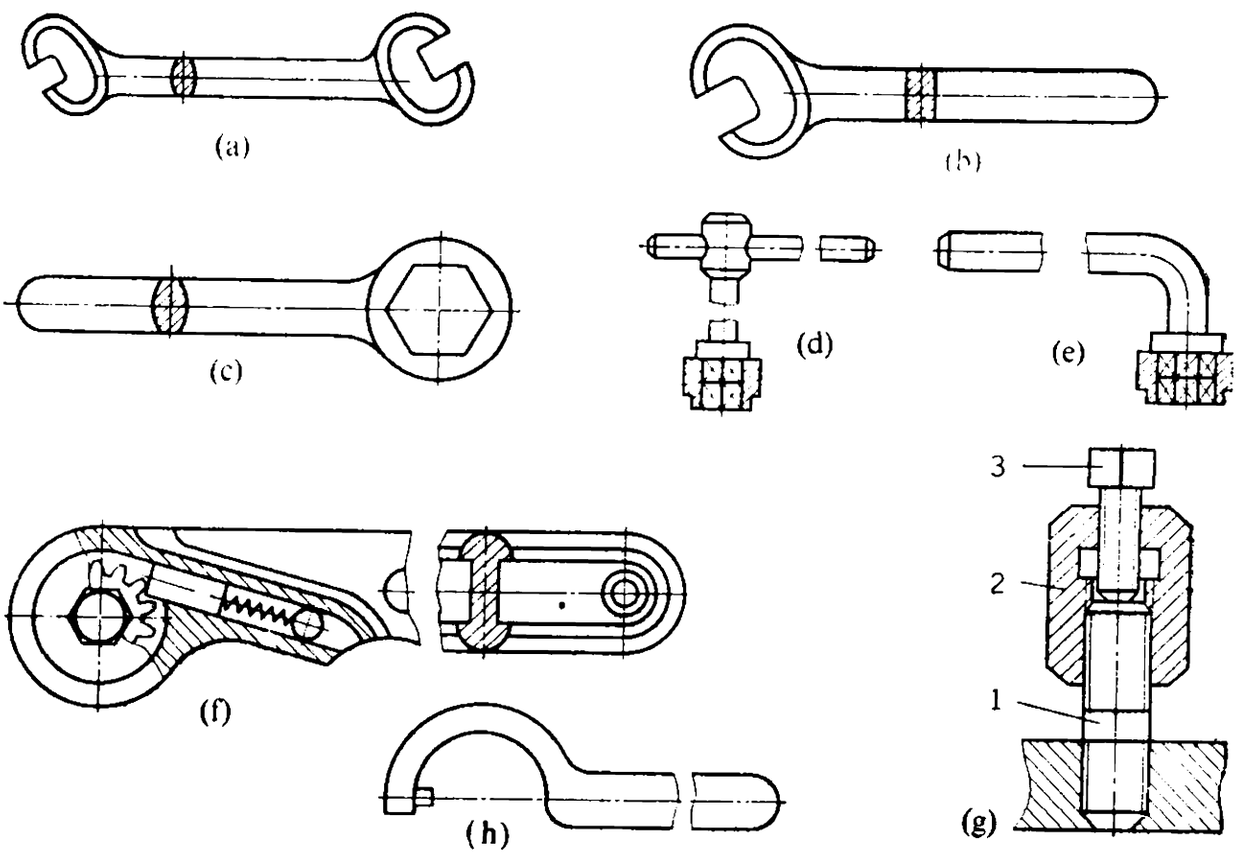


Fig. 24. Wrenches
a, *b*—open wrenches; *c*—box wrench; *d*, *e*—socket wrenches; *f*—with ratchet; *g*, *h*—special wrenches

Hammers and *mallets* may be of different types: ordinary steel mallets and soft mallets made of lead, copper, aluminium alloy, babbit, and wood. In contrast to ordinary mallets, soft mallets cause no deterioration of removed parts, but wear out rapidly. Mallets with detachable impact soft parts mounted in a steel holder prove to be more durable.

Wrenches (Fig. 24*a-h*) are intended for unscrewing and driving nuts, bolts, pins, and screws. Ordinary wrenches are of the open, box and ratchet type, while the adjustable wrenches are used for driving and unscrewing nuts of hexagonal and square section. Adjustable wrenches may be used with mouths of different dimensions, but they do not ensure good hold of the bolt or nut head. For small-size nuts and bolts located in areas with difficult access—box or hinged wrenches are used. A hinged wrench is a combination of the box wrench with a double hinged head (replaceable or constant) which allows its use even when the wrench rod is strongly inclined.

Special wrenches are used for round nuts and pins. So for instance for unscrewing pins a wrench is used shown in Fig. 24*g*. The hexagonal nut *2* is screwed on the protruding end of pin *1* and reliably locked by the screw *3*, after which, the nut is turned together with the pin in reverse direction using an ordinary wrench.

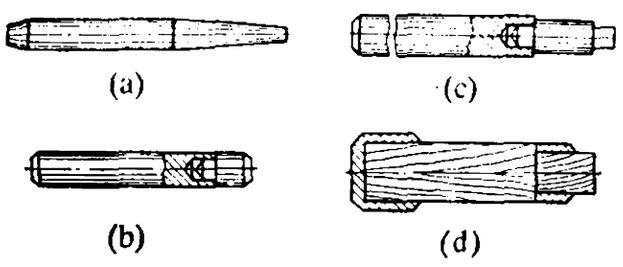


Fig. 25. Drifts
a—solid drift; *b*, *c*—drifts with removable endpieces; *d*—steel drifts

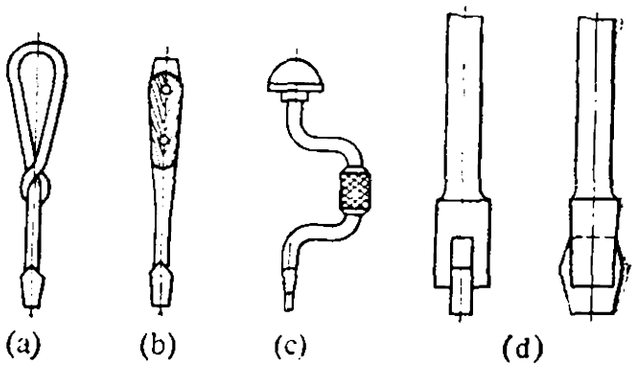


Fig. 26. Screwdrivers
a—wire screwdriver; *b*—with wooden or plastic handle; *c*—brace screwdriver; *d*—with inserted plates

The machines and looms manufactured by machine building works are supplied with a set of ordinary and special wrenches. For example, the ring spinning frame is provided with a set of 26 wrenches, eleven of which are ordinary ones, six box wrenches, and nine special wrenches.

Drifts (Fig. 25*a-d*) are used for the disassembly of units in which parts are tightly fitting in the hole. Drifts are made as solid one-piece tools of soft steel or with a removable end-piece of copper, brass, lead, aluminium, etc. The shape of the endpiece is determined by the shape of the part to be knocked out. Steel drifts with hardened working surface are used for knocking out cylindrical and bevel pins, as well as sheared cotter pins.

Screwdrivers (Fig. 26*a-d*) are used for driving in and out wooden screws, as well as screws with heads of different shapes having slots in diameter. Screwdrivers may be made of wire and have wooden or plastic handles. To facilitate the work screwdrivers of different shapes are available, for instance, brace screwdrivers or screwdrivers with inserted plates.

Strippers and *presses* are used to disassemble units consisting of parts with interference fit (pulleys, handwheels, gears, bushings, ball and roller bearings, couplings, cams, etc.)

Strippers are subdivided into mechanical, hydraulic and pneumatic types. For the repair of machines wide use is made of mechanical strippers, but when a great effort is to be applied hydraulic strippers are more adequate. Pneumatic strippers have a complex design and find rare application.

General-purpose strippers are employed for lifting parts of different shape and sizes (Fig. 27), while special strippers are used for removing parts of the same type and dimensions.

Figure 28 illustrates the hydraulic stripper. The bolts *4* are passed through the holes of the part *3* to be stripped and the disk *5*. A hydraulic jack *1* is placed between them so that the upper end of its plun-

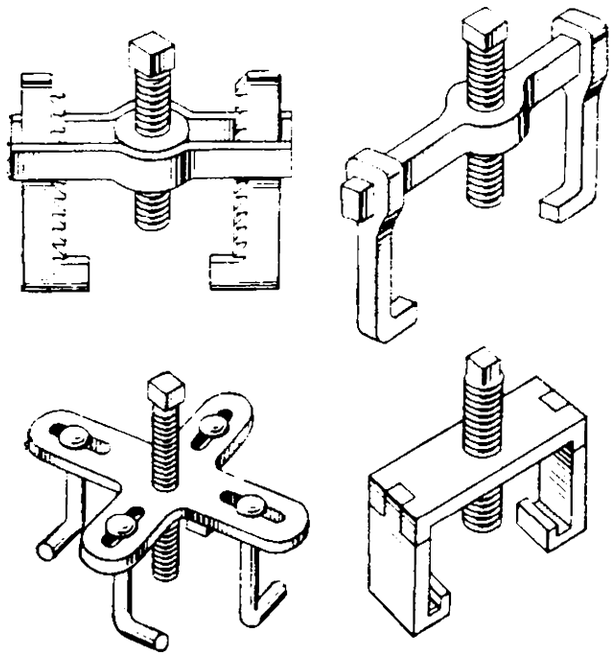


Fig. 27. General purpose screw strippers

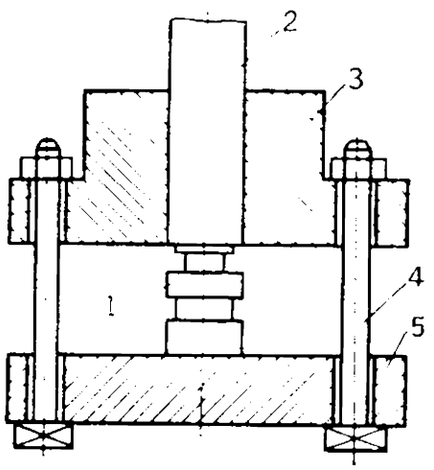


Fig. 28. Hydraulic stripper

ger bears against the butt of the shaft *2* from which the part *3* is to be removed. By pumping oil in the cylinder of the jack *1* the plunger is moved forward thus creating a pressure owing to which the part *3* may be taken off from the shaft *2*.

Presses are intended for pressing out and in bushes, gears, connecting rods, different kinds of studs and fingers, etc. Presses may be of the mechanical type with a power up to 10-15 kN or of the hydraulic type with a power up to 200 kN.

If badly rusted parts and units are to be disassembled they are immersed for a 1-2 h into a bath with kerosene, after which they are disassembled using if necessary mallets (hammers) and other tools.

Broken pins may be extracted by different methods. If the point of breakage is not very deep, slot is cut with a groove chisel and the pin is extracted by means of a screwdriver (Fig. 29*a*). Another case, a hole is drilled and threaded inside to accommodate a steel T-shaped rod (Fig. 29*b*) so as to extract the pin. Sometimes, a hole is drilled in the pin into which a square or toothed hardened steel rod (Fig. 29*c*) is inserted and to extract the pin. In the given case, use may also be made of a steel hardened rod (extractor) with five spiral grooves having an angle of spiral 30° on its conical surface. The extractor which is screwed into the hole drilled in the pin drives it out of the part body (Fig. 29*d*). If the broken end of the pin protrudes above the surface of the part, the pin is removed by means of a special eccentric wrench (Fig. 29*e*).

In some cases when it is impossible to extract the pin from the part, it is drilled out after which the hole is threaded anew; drilling

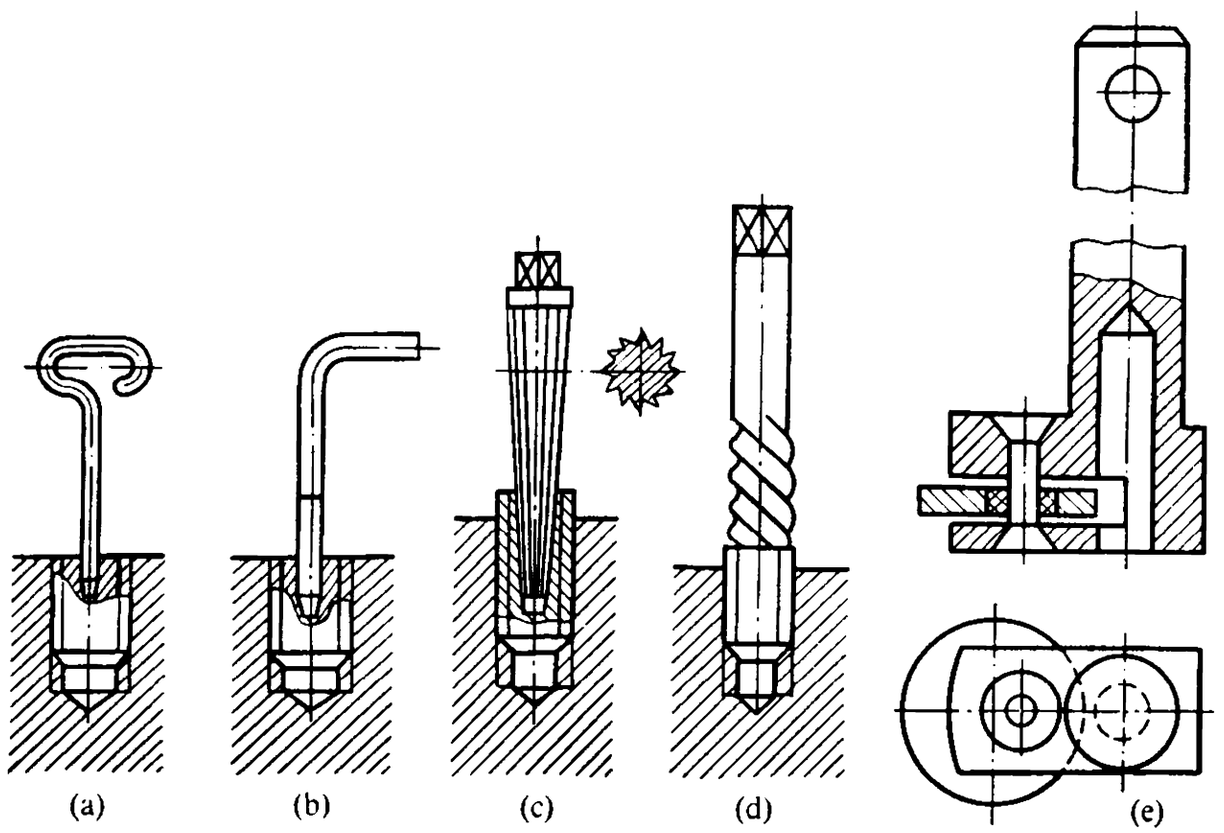


Fig. 29. Methods of extracting broken pins

is made in several passages progressively increasing the drills diameter. The broken end of the pin is eliminated also with the aid of a hollow milling cutter. Lately the electric spark method has also found application (see Chapter 2).

2. Cleaning and Washing of Parts

After they have been disassembled, the parts are cleaned and if required washed. Large-size parts (stands, frameworks) are cleaned with hand and mechanized brushes or by blowing with compressed air or by means of an industrial-type vacuum cleaner. The interior thread in these parts is cleaned with a brass wire bent as a loop with loose pointed ends.

Cleaning of small parts by scrapers, hooks and rags is inefficient and of low quality. In this case, it is more expedient to use special cleaning devices and brushes with a diameter not over 250-300 mm and having a pile 50-60 mm long operating at a speed of 35-40 m s^{-1}. Steel and cast iron parts are cleaned by metal brushes of low carbon steel wire, while for brass parts—brushes of brass wire are to be used.

Brushes of fibre cord or other synthetic materials are used for cleaning the parts from burrs and small rust as well as for eliminating dirt remained after washing.

The cleaning efficiency may be two or three times increased by using an electric polishing machine with an induction high-frequency

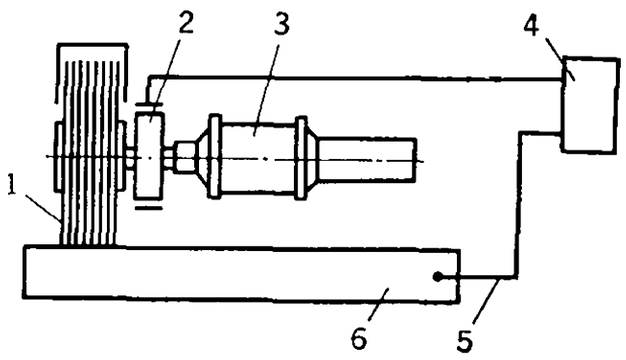


Fig. 30. Device for part cleaning

motor which is provided with a metal brush *1* (Fig. 30) instead of an abrasive wheel. This brush is powered from a transformer *4* through a contact ring *2* and copper-graphite brushes. The other pole is connected by the wire *5* from the transformer *4* through a clip to the work *6* to be cleaned. The brush *1* is rotated by the motor *3*. The impurities on the surface of the part are destroyed by electric discharges as well as by the mechanical action of the brush which at the same time eliminates them from the surface. Washing and cleaning of parts should be carried out in special premises. The parts are placed on the grate of a bath or pan. First they are washed in kerosene or immersed in a soap solution (25 g of soap per liter of water) and further treated for several hours in a solution containing 45% of kerosene, 35% of turpentine and 20% of ammonium hydroxide (industrial). Then the parts are washed with clean kerosene and wiped with cotton rags. Washing with hot aqueous solutions of alkalies is more convenient and cheaper.

For washing steel and cast iron, use is made of an alkaline solution heated to 70-80°C and having the following composition (g per litre)

First recipe		*Second recipe*	
Sodium hydroxide	10	Sodium hydroxide	23
Soda ash	7.5	Sodium carbonate	6.5
Sodium phosphate	13	Green soap	3
Soap	2		

The following solution is used for washing parts made of aluminium alloys, (g per litre):

Sodium carbonate	4.5
Sodium hydroxide	1.3
Sodium phosphate	1.45
Green soap	1

After the treatment in alkaline solution the parts are rinsed with hot water to avoid corrosion and to eliminate the remaining alkali. Washing is carried out in baths of different designs or in conveyer-type washing machines with three or four chambers, where the parts are washed in consecutive order with alkaline solutions and water and dried with hot air. Parts filled with babbitt are not to be washed in alkaline solutions.

Washing of small parts in mass production is carried out in tanks and tubs of different design using kerosene or other washing liquids.

Lately ultrasonic cleaning of parts and units has acquired wide application. Its principle is described below. High-frequency oscillations are created in the washing liquid owing to which cavitation bubbles are created which exercise mechanical action on the contaminated surface. The impact waves intensively destroy the layers of lubricant and dirt covering the part surface. Simultaneously the impurities chemically interact with the washing solution which may be an aqueous alkaline solution, solutions of synthetic surface-active substances and organic solvents.

3. Inspection and Sorting of Parts

After they have been dismantled from the machine, cleaned, washed, degreased and dried, the parts are inspected and sorted. The parts are sorted in three groups: fit for further use without repair, needing repair, and unserviceable. The first group includes parts which have retained their structural or repair dimensions or when the degree of their wear has not exceeded the allowable limits (there are no cracks and other defects and their outward appearance satisfies the specifications).

The second group is assigned to parts with modified structural or repair dimensions, having cracks and other defects but which may be repaired.

Badly worn, broken, cracked parts which are very difficult to repair and not worth to be restored pertain to the third group.

Sorting of parts makes it possible to specify defects in the list which was established prior to the complete disassembly of the machine.

The serviceable parts are collected in one place, the parts requiring restoring are sent to the shop and unserviceable parts are scrapped to the scrap yard where they are sorted by materials used for their manufacture. To replace the unserviceable parts, the repair team receives new ones from the store.

When inspecting and sorting parts, the latter are classified into three groups, i.e. movable important parts, stationary important parts and non-important ones. The parts pertaining to the third group are subjected to outward examination, while the parts of the first two groups are inspected for concealed defects, measured and examined for outward appearance.

The sorting inspector must be thoroughly acquainted with the design of machines to be repaired, the conditions of their operation and the technological process of the repair to be carried out. Special instructions and albums of drawings are used for technical inspection of parts. Concealed defects (surface and interior cracks) are uncovered by means of magnetic ultrasonic and luminescent flaw detectors.

Magnetic flaw detectors are used for the examination of steel and cast-iron parts. The part is sprayed with a finely dispersed metal powder in suspension in kerosene or transformer oil. When the part is magnetized by the flaw detector, the particles of the powder are disposed according to the power lines of the magnetic flow, while in case of a crack they run along it thus marking its disposition and shape.

Ultrasonic flaw detectors are based on the capacity of sonic waves with an oscillation frequency of 0.5-10 MHz and higher to propagate in a solid state in the shape of a thin slightly diverging jet. If there is a defect (crack or cavity) in the part it becomes an obstacle for the passage of the ultrasonic wave as the latter is partially reflected and partially dispersed. This testing method allows the detection of defects deeply located in the part.

Luminescent flaw detectors use the capacity of fluorescent substances to glow on their irradiation by ultraviolet rays. The part is immersed in bath with fluorescent liquid which penetrates in the finest cracks (if such are present). Further, the part surface is dried and sprayed with silica gel powder, and then irradiated in a chamber with ultraviolet rays. The fluorescent layer remaining in the crack starts glowing and marks out the point and shape of the crack.

The exterior concealed cracks may be determined by more simple methods. On washing and drying, the part is immersed for 10-15 min in a bath with clean kerosene, then taken out and wiped, and the point of the supposed crack is coated with chalk. If a crack is there, after a certain time a dark trace would appear on the coating due to the evaporation of kerosene from the crack. According to another method of testing, the cleaned part is subjected to etching by a heated 10-20% solution of sulphuric acid after which the surface of the part is examined with a magnifying glass.

4. Repair of Shafts

The shafts used in textile machines may be straight (the spinning frame main shaft) and shaped shafts (roving frame main shaft, loom crankshaft). The dimensions of the shaft may vary greatly, i.e. from 20 to 250 mm and more in diameter and from 200 to 8000 mm and more long. The mass of some shafts may reach several tons.

The shafts of textile machines are made of different grades of steel: structural carbon steel of standard quality or high-quality structural carbon steel. The following typical defects may be observed in the course of operation: local and overall deflections, cracks, breakages, wear of running surfaces, crushing of keyways, deformation at places intended for fitting other parts, stretching and stripping of thread, etc.

Bent shafts. Usually bent shafts are straightened in cold condi-

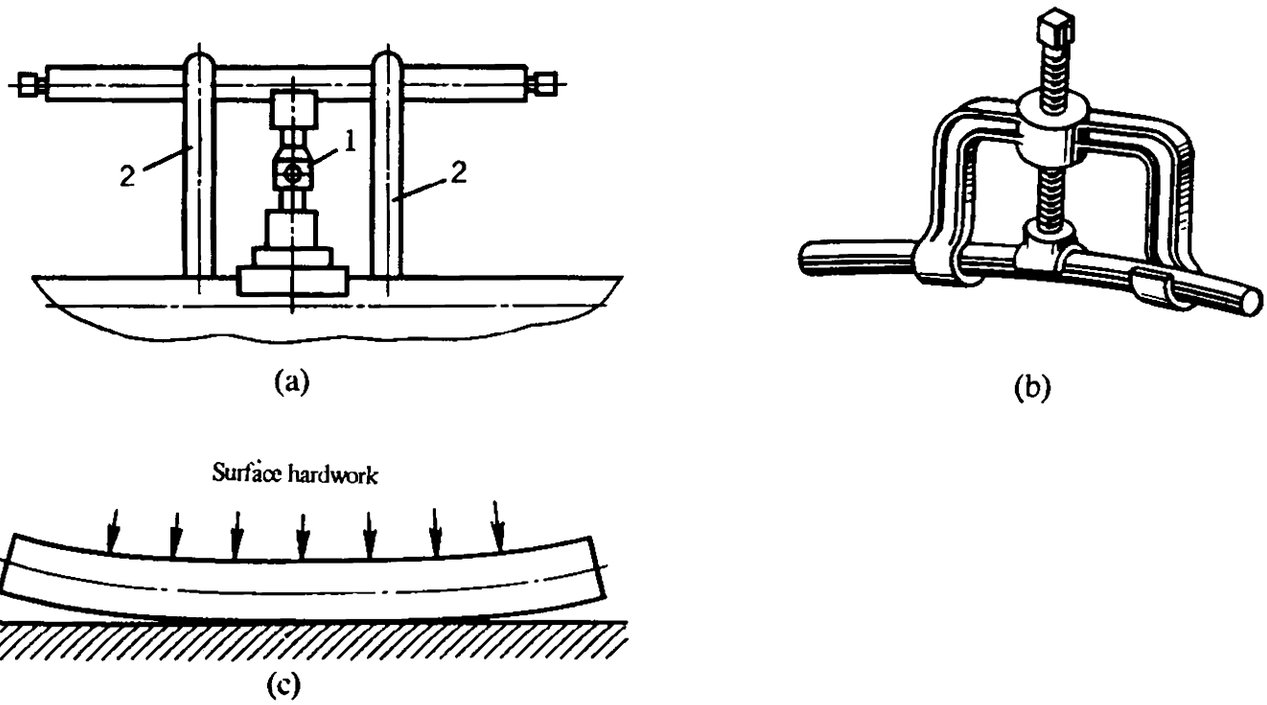


Fig. 31. Straightening of bent shafts

tion. The main disadvantage of cold straightening is an unbalanced state of the shaft after straightening. However, cold straightening ensures a higher precision and is much easier than hot straightening. Cold straightening is carried out in a press equipped with centres or fulcrums as for instance in a hydraulic press.

If there is no hydraulic press available, straightening may be carried out on an old turning lathe using a screw jack *1* (Fig. 31*a*) and hooks *2* or a special clamp (Fig. 31*b*). The accuracy of cold straightening would in this case be 0.05-0.15 mm per running metre of shaft. Shafts which are slightly bent (0.03-0.05% of the shaft length) are dressed by surface cold work using a pneumatic hammer. Figure 31*c* shows impact load application for obtaining cold work hardening.

Shafts of greater diameter (over 50 mm) including shafts with a considerable deflection are straightened in hot condition (heated to 750-800°C) by means of a sledge hammer or an ordinary hammer. The accuracy of straightening is 0.5 mm for one running metre of the shaft. The surface of the shaft may be damaged in the course of hot straightening and moreover the cost of repairs in this case exceeds that of cold straightening.

Cracked and broken shafts. These are restored by welding and by inserting new parts mechanically or in combination with welding. Shafts with very deep cracks are made broken and repaired as broken shafts. The crack must be broken to the full depth so that it could be reached by electric arc, heated to full depth and rapidly welded up*.

* Cracks are welded up rapidly so as not to make parts brittle.

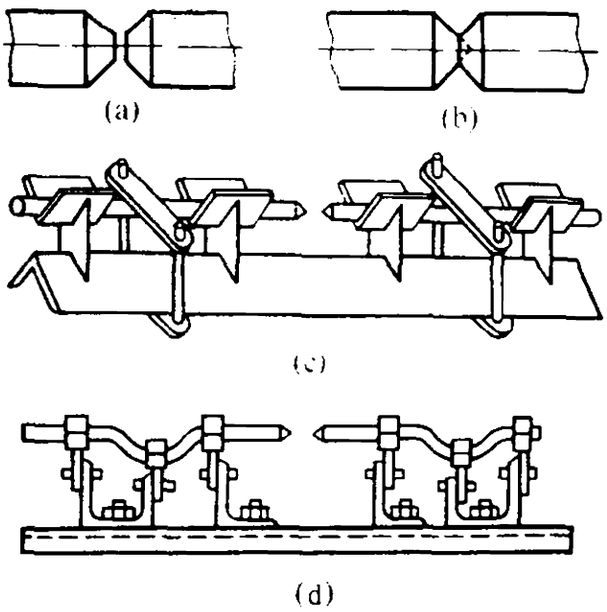


Fig. 32. Preparing shafts for welding and jigs for shaft welding

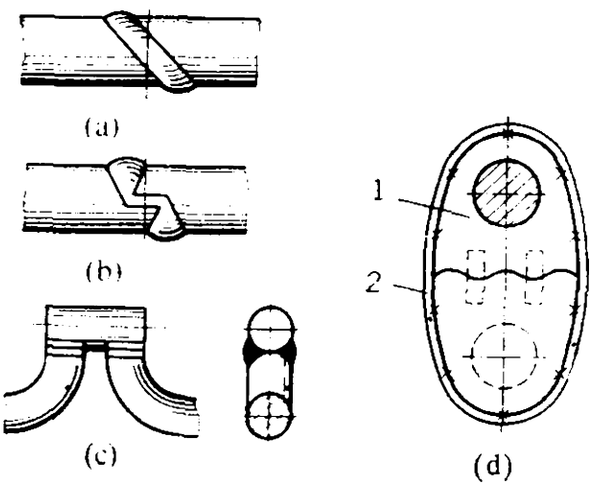


Fig. 33. Repair of broken shafts by welding

The shaft ends to be butted are prepared for welding as follows (Fig. 32*a*, *b*). Prior to welding, marks are made on the shaft at equal distances from the point of breakage which is necessary for checking the shaft length. After cleaning the butts, the parts of the shaft to be welded are set in place, centered and secured in jigs of adequate design depending on the shape of the shaft. Figure 32*c* shows the jig for welding straight shafts, while Figure 32*d*—for welding crankshafts. Figure 33*a* and *b* shows how the welding joint is strengthened.

Sometimes new parts (necks, journals, etc.) are welded to the broken shaft. For instance on the loom crankshaft with a crack on its neck, a new neck is welded (Fig. 33*c*) as welding of the old neck is impractical and reinforced weld seams cannot be applied. In case the crankshaft jaw is broken joining is made by inserting two pins into the butt, a band *2* is placed on the jaw *1* (Fig. 33*d*) in hot state and welded. After welding, the shaft is checked for deflection and if necessary straightened. Bulges formed at the point of joining are removed on a lathe and if possible left in place.

Worn-out shafts. The following parts need repairs due to the wear of shafts: journals, surfaces for mounting pulleys, gears and other parts, keyways, threads, etc. The main kinds of repairs of a worn-out shaft are: building-up (hard facing) of the worn-out surface, metal coating or electroplating, placing a ring on the worn plate, or the use of repair sizes in shafts to be repaired. If the wear and crushing of separate shaft elements are very great, new elements are built-up by welding or by a mechanical process in combination with welding. The kind of repairs is a function of the extent of wear, the conditions of shaft operation, the availability of repair facilities

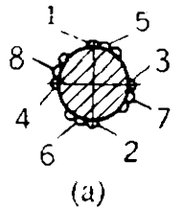


Fig. 34. Restoring broken shafts by building-up

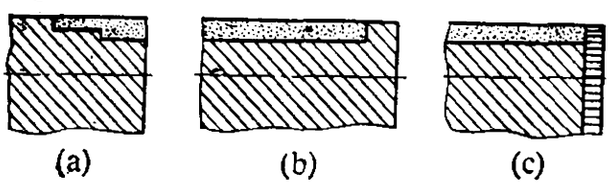


Fig. 35. Repair of worn shafts by metal coating

and of the use of repair dimensions system, as well as economic considerations.

In repairing shafts by *building-up* their worn-out surfaces (journals and necks) must be prepared so that the metal overlay is of about the same thickness. The welding beads are placed in an increasing order (Fig. 34*a*) or as a spiral (Fig. 34*b*). This sequence is necessary to prevent shaft warping in building-up. Breaks in the building-up process (for turning the part or cleaning the beads) serve to equalize the welding temperature conditions and to partially protect the part from warping.

The crushed or stripped thread is cut off by a cutter and built-up with a big allowance for further machining.

In centralized repairs of shafts, the building-up of worn-out places should be carried out automatically on special machines under a layer of flux (see Chapter 2).

When the shafts are repaired by *metal coating*, their surface should be prepared to eliminate the distortions of its geometrical configuration and to increase the surface roughness. On the surface of the shaft to be metal-coated a rough thread is cut with a pitch of 0.8-1.2 mm and a depth of 0.5-0.8 mm. Then the surface is cleaned from oil stains and dirt by sand blasting. If the journal end is worn out the surface to be metal-plated must be stepped (Fig. 35*a*) to avoid the loss in journal strength and to retain the pulverized layer. To prevent the end surface from flaking and to strengthen it, safety beads are made by turning or welding (Fig. 35*b*, *c*) or also slots may be cut on the surface.

In metal coating shafts of intricate shape (crankshafts, shafts with shoulders, flanges, etc.), they are first coated with sprayed metal at places of sharp changes (cranks, ledges, etc.) and then the rest of the surface is sprayed with metal. Metal-coated shafts are machined on lathes as usual.

Chromium plating of shafts is carried out as follows: grinding and buffing of the surfaces to be chromium plated; insulating places which are not to be chromium plated, and screening sharp edges and relief points, sand papering; suspending parts from frames, electrolytic degreasing; washing in hot water; etching and chromium plating; washing in running cold water; neutralizing in an alkaline solution;

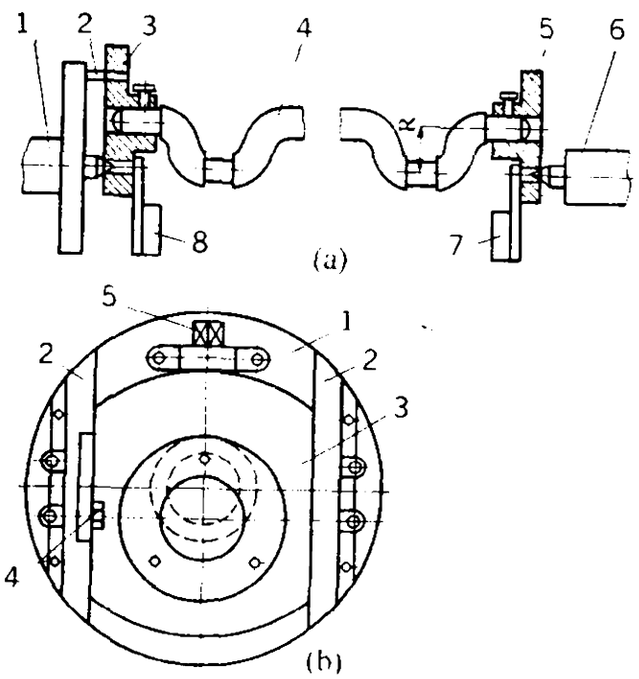


Fig. 36. Centre shifters

rinsing in hot water; removing the parts from the frame; washing in hot water on nets; inspection; if necessary machining of the chromium-plated surface.

When preparing the shafts for *ringing*, the worn-out journal is turned to obtain a regular shape and the size necessary for appropriate fit. The minimum diameter of the turned place is determined by calculating the strength of the journal. The worn-out journals are fitted with solid rings (couplings) and composite rings are placed on the necks. When necks and journals are passed into the group of parts with repair dimensions they may be restored by turning, or by turning with subsequent grinding, or by grinding only. In case of considerable distortion of the shape, untreated necks and journals are usually turned on a lathe and then ground. When the distortion is inconsiderable, grinding is sufficient. The allowance should be the same as for new shafts.

The aim of *machining* is to impart the shafts definite shape and dimensions after welding, building-up, metal spraying, chromium plating and also to use the repair dimensions of the part.

When choosing conditions for the machining of built-up and metal-coated shafts, it should be taken into account that the hardness of layers is usually higher than that of the parent metal, the surface of coating is not smooth, etc. For this reason, it is necessary to use a lower cutting speed, depth, and a smaller feed as compared with those recommended for working the parent metal.

When turning the neck, the crankshafts are fixed in special devices—centre off-setting fixtures. The simplest centre shifter designed for one radius R (Fig. 36*a*) consists of two chuck plates *3* and *5* and counterweights *8* and *7*. The shaft *4* is attached in the central holes, while the shifted holes are used for clamping the chucks in the centres of the headstock *1* and tailstock *6* of the turning lathe. The shaft *4* is rotated by the carrier stud *2* at the rotation of the headstock spindle.

The universal centre shifter (Fig. 36*b*) consists of the chuck plate *1* with guiding plates *2* and movable slides *3*. The chuck plate *1* is screwed on the end of the lathe spindle to the slides *3*; the chuck (not shown) fixed with three screws has prismatic jaws in which the shaft end is held. The slides with the chuck are displaced along the

guiding plates *2* by the screw *5*. The amount of shifting of the shaft axis is controlled by the vernier rule *4*. To avoid strong vibrations impeding machining the crankshaft must be balanced by counterweights.

Straight shafts are ground in circular grinders with special grinding heads.

Shafts with worn-out necks may also be restored by applying a layer of polyamide polymer. In this case the working surfaces of the sliding friction bearings may be made not only of hard antifriction materials, but also of hardened steel. Such combinations of friction pairs are called opposite in difference from direct pairs when the working surface of the shaft is of steel and that of the bearing of antifriction material. The advantages of opposite pairs are an easier elimination of rubbing heat, smaller wear of rubbing surfaces and a higher strength of the plastic coating.

5. Repair of Bearings

The antifriction and sliding bearings used in textile machines are of most various designs, yet sliding friction bearings only are repaired in textile enterprises. The repair of antifriction bearings is carried out in special bearing repair plants as complicated special equipment is required for this kind of repair.

Sliding bearings may be classified into solid bearings (with or without bushes) and split bearings (with or without linings). Many machines have open bearings (e.g. for fluted rollers of spinning frames).

The bearing shells are mainly made of cast iron, while the bushes and linings are made of antifriction cast iron, bronze, zinc and aluminium alloys, metal ceramics (cermet), hard plastics and laminated wood plastics. Also used are bimetallic linings and bushings; cast iron or steel linings and bushings lined with babbitt, bronze, zinc, aluminium and other antifriction alloys. Some bearings (for instance on the shaft of the drawing frame coiler) are cast as a whole with a bracket.

The main drawback of sliding bearings is the wear of rubbing surfaces and sometimes their cracks and breakages. Depending on the type, dimensions, materials and kind of defects the bearings are repaired by different methods: metal coating, building-up, pouring with babbitt and bronze, pressing the repair bushings, replacing the worn part, and plastic compression.

Metal coating may be used for the repair of bearings of different designs with the exception of long bearers with deep holes of small diameter (for instance spindle tubes and bolsters). When preparing the surface of a bearing or bushing for metal coating, i.e. when eliminating their ovality or conicity by boring and cutting a rough thread, care should be taken that the walls of the workpiece are

not excessively weakened. If the bearing is strongly worn-out, the rough thread is to be cut without preliminary boring.

Split linings are prepared for metal coating proceeding as follows. Both halves of a bearing are connected by a clip or soldered together after which they are carefully checked (trued) and secured in a device on the lathe, bored, and rough threaded to a depth of 0.8 mm.

The split bearings without linings are tightened with bolts and clamped in a four-cam chuck or on the carriage of a turning lathe. The non-split bearings are metal-coated in the same manner. Split linings and bearings are sometimes metal coated in disassembled state manually for obtaining a more uniform metal layer through the use of thickness gauges.

Metal-coated bearings are subjected to heat treatment in a reducing medium at 700-750°C for 2-3 h. This increases the strength of the part and moreover improves the antifriction property and the wear-resistance of the part. After metal coating the bearings are bored and reamed and the split linings are complementary scraped. The allowance for machining must be 0.6-0.7 mm at each side.

Building-up. If there is no metal coating plant at the enterprise the bearings and linings are repaired by building-up. Building-up is made with the same materials from which the workpieces have been manufactured. However the antifriction properties of cast-iron linings and bearings are considerably increased by building-up with bronze. The worn surface is prepared for building-up by boring. After the mechanical treatment, the layer of built-up metal must not be under 1 mm. It is recommended to make longitudinal grooves in dovetail shape on the bearings so that the built-up metal is more reliably retained on the surface.

Building-up is done by electric arc or gas welding. Preliminarily the parts are slowly heated: cast-iron linings—to a temperature of 500°C, and bronze linings to 400°C. Building-up is carried out according to a thickness gauge which ensures a greater uniformity of the layer. The allowance for machining is 2-3 mm. After building-up the bronze linings are annealed at a temperature of 500-550°C, then cooled in water. The built-up linings are bored, reamed and scraped.

Lining of bearings. Sliding bearings lined with non-ferrous antifriction alloys: babbitt, bronze, zinc and aluminium alloys, polymer materials, etc. find wide application in textile machines.

If the lining of alloys is worn out it must be removed, and a new lining made. When lining the bearers with babbitt the following operations are to be made: cleaning, degreasing, eliminating the worn layer of babbitt, tinning of bearings, shaping forms of bearings to pour the linings; melting and lining with babbitt; machining of bearings lined with babbitt.

The worn layer of babbitt is removed by heating with a soldering torch, melting-out in special electric furnaces, immersing the bearer

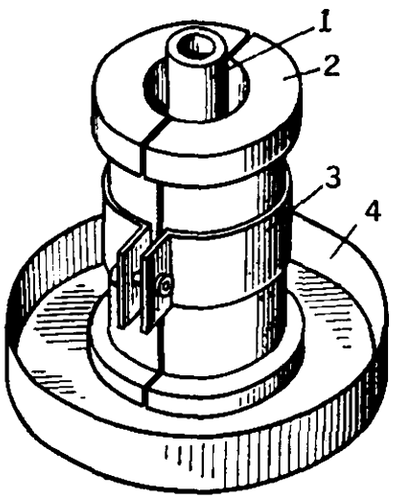


Fig. 37. Device for babbitting linings

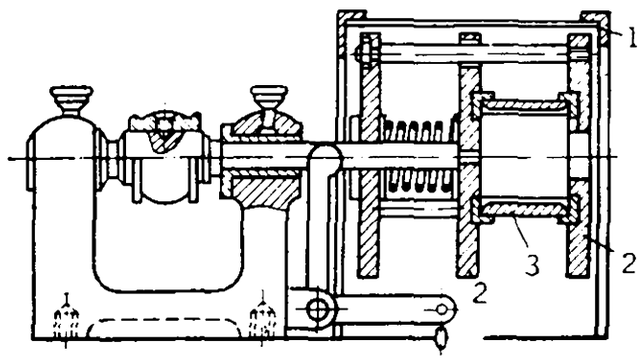


Fig. 38. Machine for centrifugal lining of bearings

in a crucible with molten babbitt or knocking it out by means of a chisel. The best method for eliminating the worn-out layer of babbitt is its melting-out in electric furnaces.

In order to obtain a good joint between the babbitt and the lining, the surface of the lining is covered with a thin layer of tin. Tlhis process is called tinning. The layer of solder or tin ensures a ceose joining of the babbitt with the lining owing to the mutual penctration of metal into the other. A mixture of lead, tin and sodium thloride is used as a solder. Sometimes leading is superceded by inning. In this case pure lead is used as a solder. The bearings and linings of gray cast iron are not tinned, but may be copper-plated.i

After tinning, the linings are formed in special devices (Fag. 37). Both halves of the linings *2* are tightened with a screw sh eckle *3* and an asbestos or untinned iron gasket is placed between th r faces of the joint, so that it reaches the rod *1* and prevents the solde ing of the two halves together. The form is mounted on the pan *4* retaining in place the babbitt at pouring. The rod *1* (or core) made of a pipe, sheet material, or dry tight wood is placed strictly in the centre. The rod should be slightly slanted for better convenience of driving it out. The diameter of the rod is chosen to suit the thickness of the poured layer, the allowance for machining is 1-1.5 mm, and the shrinkage of babbitt 0.7-0.5%.

Prior to babbitting, the device is heated with a soldering lamp to a temperature of 150-200°C and the lining to 250-270°C.

Babbitt is melted in deep cast iron or steel melting pots heated in an electric furnace, by means of a soldering lamp or in a forge. Pouring should be done quickly and without interruptions, otherwise the babbitt may peal off. The poured linings are taken out from the device only when the babbitt gets completely hardened.

Pouring may be also carried out by the centrifugal method using a special device (Fig. 38) which may be manufactured using an old

lathe. Tinned, tightened and preliminarily heated linings *3* are fixed in the clamping device *2* and closed with the housing *1*; then the lathe drive is switched on. Pouring is done after the rotational speed has been accelerated to the preset value. The centrifugal method of lining is more efficacious and ensures a better quality of lining. The molten metal introduced into the hollow hot rotating cylinder (lining) is rejected by centrifugal forces to the cylinder walls to which it adheres fastly. The babbitted linings are bored and scraped at the assembly.

Both new and repaired bearings are lined with bronze owing to which they are imparted higher strength and wear resistance. For this reason, bronze is used for lining heavily loaded bearings. Lining with bronze may be done both manually and by the centrifugal method. Lining with a zinc alloy is usually made on the untinned surface of bearings, while lining with aluminium alloy may be done only when the layer is mechanically attached to the surface of the lined bearing. For this reason it is necessary to provide circular grooves or to cut a thread on the surface of the bearing. Lining may also be made of polymer materials.

Repair by mechanical methods and presswork (plastic deformation). Worn-out bearings, linings and bushings are repaired depending on their design either by mechanical methods (by placing inner rings, inserts, and patches) or by presswork (plastic deformation). Heavily worn-out solid bearings are repaired by pressure, placing repair rings (bushings) of antifriction material (cast iron, bronze, aluminium and zinc alloys, fabric-base laminates and other plastic materials).

The exterior diameters of the repaired rings depend on the chosen fit and class of accuracy, while the internal diameter of the ring (bushing) corresponds to the dimension of the new part or to the next repair dimension. At pressure fitting of rings (bushings) their interior diameter and shape are reduced and for this reason when choosing the interior diameter of the ring it is necessary to take into account the allowance for the final machining in assembly (reaming). Multi-pillow blocks are subjected to reaming in an assembled and installed state. Sizing may be also done with a ball or punch.

Splitted and open bearings without linings are repaired by installing repair semi-rings. In this case the worn-out pillow block is bored and semi-rings or linings of antifriction material are secured on dowels or with glue.

Bearings and bushings of complicated design and cast as a whole with flanges and brackets are also used in different machines (the bushing of the side wall of the card taker-in, the bearing of the roving frame shaft, and others). When repairing such pillow blocks the worn-out part is cut off and a new one is put in its place.

When repairing bearings with pressure fitted bronze bushings and split linings use is made of different methods of plastic deformation, i.e. heading, reducing and straightening for reducing the dia-

meter of the interior worn-out surface of the part.

Heading of worn-out bushings, pressure-fitted in the bearing proceeds from the butt ends around the shaft at a high pressure; as a result, the diameter of the inner surface of the bushing is reduced. If the bushing has an oval hole it is reamed prior to heading.

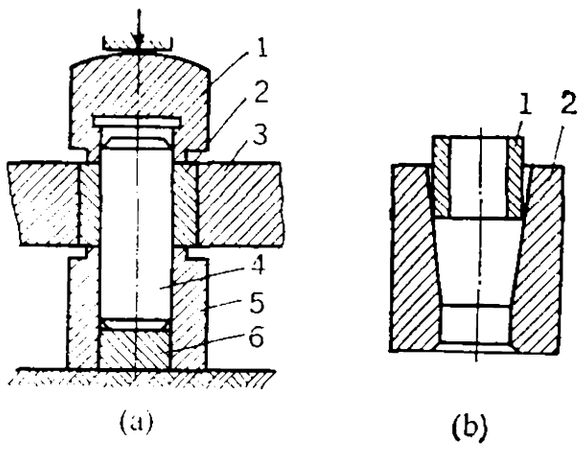


Fig. 39. Diagrams of devices
(*a*) for heading; (*b*) for reducing worn bushings

Figure 39*a* illustrates a device for heading worn-out bushings. It consists of the steel hardened die *1*, counter-die *5*, plunger *4* and support *6*. The bushing *2* to be headed and the parts *3* in which this bushing is fitted are attached in the said device. Heading is carried out in a press.

Reducing is used to decrease the worn-out hole in bronze bushings which are not pressure fitted in the bearings. The bushing *1* (Fig. 39*b*) is inserted into a steel hardened die *2* and a punch is run through it in the press. The die *2* has a gradually decreasing hole to obtain a progressive reduction of the bushing.

If the bushing has ledges (as spindle bushes in linen roving frames) the reduction is carried out by means of rollers. After the reduction, the bushing is reamed. The outside diameter of the bushing after reduction decreases and it must be built-up by metal plating, copper plating or by any other means after which it is machined in an arbor.

Split bronze linings with walls of inconsiderable thickness and subjected to strong wear are repaired by straightening. Both halves of the lining tightened with shackles are compressed in a screw press after which the halves are taken apart, the points of butt joints are planed or milled, and chamfered at an angle of 45° for soldering. This done, the halves are again tightened together and the precision of assembly is checked to avoid misalignment after which the linings are soldered along the chamfers. The exterior surfaces of the pillow block fillets (girths) and the inner surfaces of shoulders are metal-plated or built-up with brass or bronze, taking into account the allowance for subsequent machining. After coating the shackles are removed and the lining is machined on a lathe. The inner diameter is bored and the outer built-up surface is turned to the required size, while the inner surfaces of the shoulders are cut. All other surfaces are dressed. Finally, the lining is taken apart (unsoldered), the inner edges are filed and the both halves are scraped on the place of straightening.

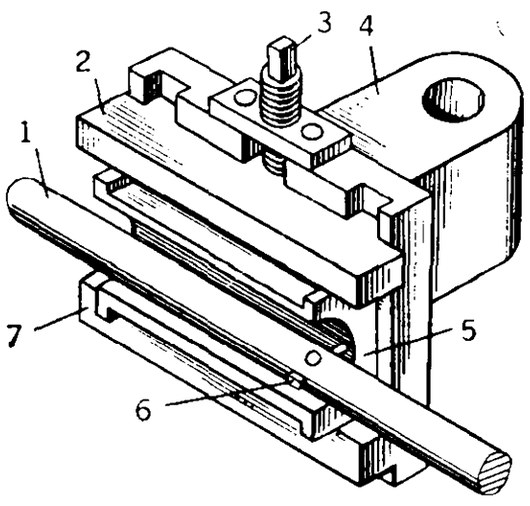


Fig. 40. Device for boring bearings

When repairing sliding bearings they must be subjected to boring. With this aim, special devices are provided in textile enterprises. Figure 40 illustrates a fixture for boring the bearings of preparation machines and spinning frames in flax mills. The fixture consists of the body *4* with two movable jaws *2* and *7* arranged in guiding slots with a dovetail shape. These jaws may be brought together or set apart by a screw *3* with a left- and right-hand thread. This fixture is attached on a lathe. A boring bar *1* with the cutter *6* is fixed in the centres of the lathe; and the bearing *5* to be centrally bored is placed between the jaws *2* and *7*. The boring bar is imparted rotation and the fixture carrying the bearing is moved in longitudinal direction.

6. Repair of Gears and Pulleys

Gears used in textile machines may be of most different kinds: spur and helical gears, cylindrical, bevel and combined gears, worm gears, and special gears with external and internal toothing; solid and split gears with different angles of meshing (for machines of Soviet and foreign makes); with various modules (from 1 to 15 and higher) and with different number of teeth (from 5 to 250); made separately or as a whole with other parts; manufactured as single gears or a train of two, three and more spur cylindrical gears.

Gears may be of cast iron, steel, bronze, fibre-based laminates, capron, leather, etc. They operate at different speeds (from 0.2 to 30 m/min) and transmit different powers. The accuracy of gear manufacture is from coarsely machined to polished ones. The number of gears and toothed quadrants and racks exceeds 100. In the course of operation different kinds of damages occur: wear and breakage of teeth, cracks in the rims and spokes, crushing of butt faces, hubs, walls of key grooves and holes, deterioration of thread in stopping holes.

Faulty gears are replaced in couples by new ones at the repairs. If there are no reserve gears available or in urgent cases, the gears should be repaired.

Gears with worn-out and broken teeth are repaired by building-up, fitting of tyres or toothed sections and by using cap-screws; and in some cases the gear is turned to the other side to make use of good teeth.

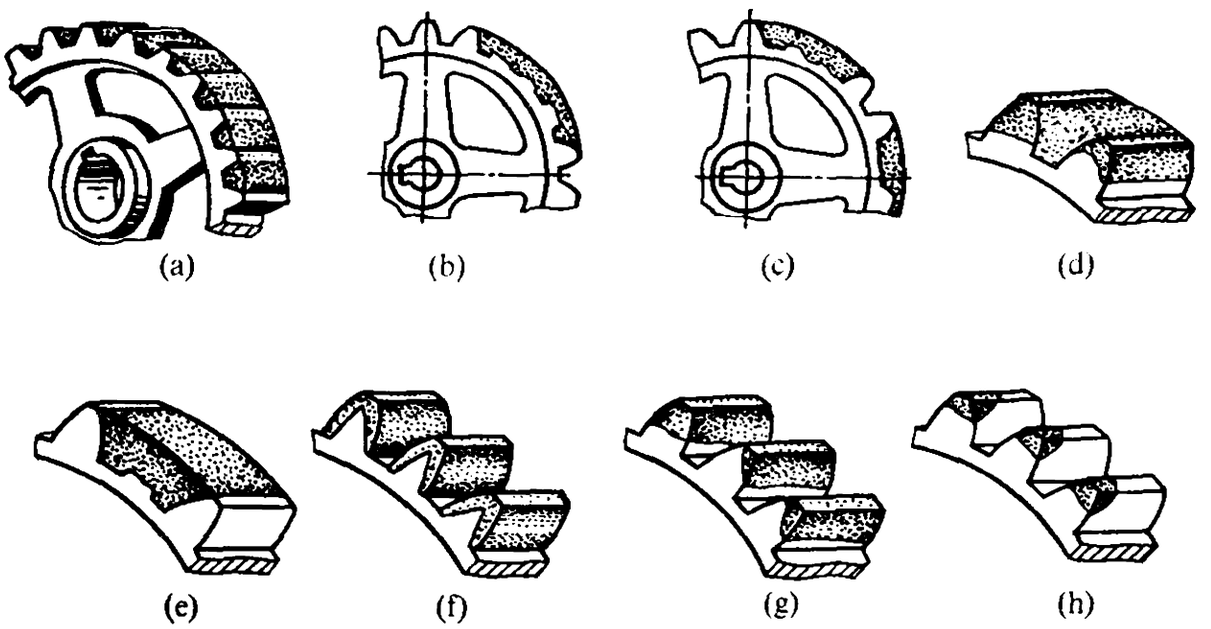


Fig. 41. Kinds of gear building-up

The toothed surface is repaired by overall circular building-up (Fig. 41*a*), building-up of separate damaged teeth (Fig. 41*b-e*), and building-up with the formation of tooth contour (Fig. 41*f-h*).

Overall circular building-up as well as building-up of separate teeth are used to repair gears having fine pitch, while welding with formation of teeth contour is employed for repairing gears with a big pitch.

Building-up is made by electric arc and gas welding with preheating (hot building-up) or without it (cold building-up). Hot building-up is usually used for the repair of big gears. If the broken or worn-out teeth are disposed in different places of the gear circumference, building-up should be carried out successively in diametrically opposite places to avoid warping and cracking. Cold building up is employed at the repair of cast-iron gears with small pitch and diameter and especially for the repair of toothed quadrants.

When repairing gears with a sufficiently strong rim, several steel pins (cap-screws) with a diameter inferior to the thickness of the tooth are screwed-in in place of the removed tooth.

After building-up, the gears are subjected to mechanical treatment. The gears whose teeth have not been formed in the process of building-up are machined as follows: the butts are cut to suit the width of the gear; they are machined on a lathe to the exterior diameter; the teeth are milled and ground. Gears with teeth formed by building-up are manually worked to the marking out. In this case, it is recommended to grind off the preliminarily built-up metal with a grinding wheel and then to proceed to milling.

For fitting segments of gears and tyres, worn-out or crumbled teeth are removed and replaced by new ones. Segments of gears are used

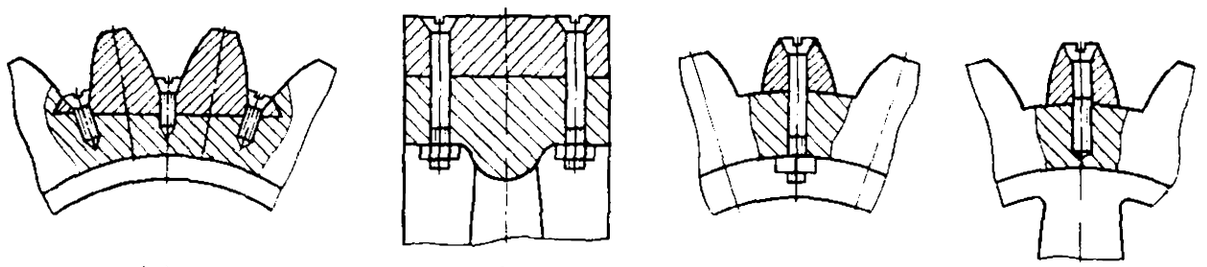


Fig. 42. Securing segment gears on threads

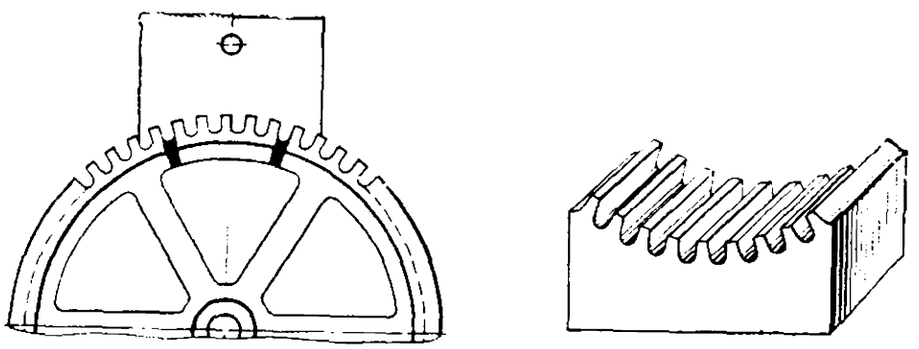


Fig. 43. Welding-in of segment gear

when there are several (2-4) adjacent damaged teeth; individual teeth are used if there is one or several damaged teeth disposed in different places; toothed tyres are employed in case of wear or breakage of the greatest part of teeth.

Worn or broken teeth are removed on a planing or milling machine, after which the place for the new segment gear or tooth is planed or milled and the segment gear or tooth is secured by screws or welding (Fig. 42*a-d*).

Welding of segment gears is less labour consuming and ensures better results. The part of the rim with faulty teeth is cut out from the gear to be repaired and in its place a good segment gear (Fig. 43*a*) is welded-in with the aid of a cast aluminium template (Fig. 43*b*). After welding is completed, using a vernier caliper and an indicator checking is carried out to verify the pitch between the extreme teeth of the segment gear and the teeth of the gear, the parallelism of the segment teeth and the basic teeth, the outside, base and pitch diameters of the gear. This done, the repaired toothed wheels are run-in at the place of installation of the segment gear with the master or mating gear which is brought in reverse motion either on a special device or manually. This is done to make the profile of the segment teeth correspond to the profile of the basic teeth of the gear and to avoid gear vibration and non-uniform wear of the mating gear.

Tyre fitting is used for the repair of gears made as one whole with other parts (intricate bushings, sleeves, gears, etc.). The tyres may

be made of steel, bronze, or cast iron. The shape and dimensions of the tyres depend on the design of the gear to be repaired and on the method of its joining with the tyre (by fit, splines, rivets, and bolts).

The tyre may also be filled with molten metal or polyamide. In order to obtain a joint of greater strength between the tyre and the base, an annular groove is made and several holes are drilled along the circumference. After fitting or pouring, the tyre is subjected to finishing and the teeth are cut.

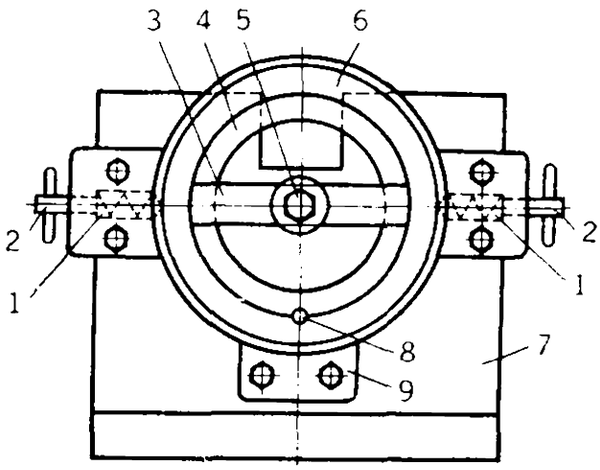


Fig. 44. Diagram of device for shaping inner teeth on horizontal shaper

When repairing the worn-out gears in flax roving frames, the teeth are cut off and in their place a steel ring or tyre is pressure-fitted by the hot method. Further the tyre is turned and milled. Cast-iron tyres are also pressure-fitted at the repair of roving frame differential gears, drawing frame gears, etc. In duplex tooth gear cast as a whole, the smaller gear wears quicker. At repairs the worn-out gear is removed by turning and a new one is installed in its place being secured with a spline or a stock screw. In case of teeth wear on bevel and worm gears (as for example the roving frame bevel gears or the opener worm gear) the teeth are cut-off by turning and in their place a toothed tyre is bolted or riveted.

The teeth of cylindrical gears, when repaired, are usually cut on milling or gear-hobbing machines (if there are no gear shapers and planers available).

The built-up or inserted teeth should be worked so that their pitch, profile and dimensions do not differ from those of undamaged teeth. If this is not the case, the meshing of the repaired gear will be irregular and cause impacts and rapid wear of the mating gear.

Bevel gears are cut in special machines, such as gear planers, or all-purpose milling machines (with lower precision).

Many machines use gears with interior toothing (such are the rim of the differential gear in a roving frame, the plate gear of the planetary warp stop-motion of an automatic loom, etc.). For the repair of such gears special gear-shapers or other devices are necessary, e.g. for cutting the interior teeth of the differential gear rim in a roving frame (Fig. 44). The rigid cast angle *7* with a wide slot in its upper part is attached on the table of a gear shaping machine. The rim *4* to be shaped is secured in the master gear *6* by the plate *3*, the bolt *5* and the pin *8*. The master gear *6* rests on the block *9* and is fixed in required position by two locks *2* pressed by the springs *1*. The cutter

which is shaped to fit the tooth space is secured with its cutting head turned upwards in a special arbor. After one tooth has been shaped, the locks *2* are retreated, the master gear is turned through one tooth and fixed in this position. All the teeth are shaped in the same way.

Gears with teeth worn-out from one side may be used without repair. For this, they are turned about 180° and made to operate with the unworn side. Gears which operate without rotation, i.e. only part of the teeth is subject to wear, may be used for further operation by turning them on the shaft to make use of the good teeth. For instance, the worm gear of the building mechanism in spinning frames operates with only several teeth. When the latter are worn out the gear is turned through a certain angle and a new keyway is cut in the hub. Thus, the useful life of gears is increased several times.

Sometimes if cracked or broken rims of gears, pulleys, and flywheels cannot be replaced by new ones, the worn out parts are repaired by welding the cracks and welding-in the crumbled part of the wheel rim. To eliminate stresses appearing in welding, the part must be slowly cooled. It is also possible to weld cover plates on the inner side of the cracked or broken rim or cover plates and moreover screw couplings may be used for repair (combined method).

The best method for repairing the cracks appearing on one or several spokes is by hot or cold welding. In some emergency cases one or two cracked spokes (disposed at different places) may temporarily be tightened together with a clip. For better reliability the cracked spoke must be welded after which a clip is put on. Crushed keyways are filed up or new keyways are cut at some other place and the crushed ends are built-up or cut.

7. Assembly of Equipment

The proper operation of equipment depends on its correct assembly. The parts must be received for assembly only after their checking in the technical control department. Prior to the assembly, the parts are cleaned from dust and their working surfaces should be in proper condition and without defects (impressions, scratches, indentations, etc.). The assembled equipment as well as its units and mechanisms should have clean rubbing, contacting and interior surfaces without chips, scale and dirt. After final assembly, no drilling of holes, thread cutting, etc. should be done in the mechanisms to avoid chips getting on the rubbing surfaces. All butt joints of parts (covers, pipe unions, etc.) that are fixed to the body and containers must be tight so as to avoid leakages. Good sealing of the joints should be checked at testing of the assembled machine. No minium or white paint should be used to ensure a good sealing in pipe connections with nipples and other design packings.

To avoid residual deformation at the assembly of steel parts no heating above 300°C is allowed for the enveloping part. Heat-treated parts may be heated during assembly at a temperature not exceeding the tempering temperature. Centre punching and knurling with a roller for restoring the part dimensions are not allowed. Filing of cylindrical surfaces for mating is also forbidden. Rapidly rotating parts should be balanced to avoid causing vibrations. The disbalance should be within permissible tolerances.

Prior to their installation in place, ball and roller bearings must be cleaned from oil and dirt, washed in an anticorrosion solvent and dried. The level of liquid lubricant must be at the axis of balls in their lowest position. The grease should fill not more than two thirds of the free space in the frame cavity at low and medium rotational speed of bearings and not over 1/3-1/2 at high rotational speed. In the course of assembly, use is made of presses and erection tubes to ensure the proper fitting of rings without misalignment and to avoid scoring of the setting surface. It is forbidden to hit directly the bearing with a hammer. At the time of erection of solid bearings in the frame and on the shaft simultaneously the pressing effort should be applied to the ring with an interference fit. The adjustment of the bearings must exclude the jamming of balls or rollers. Special attention should be paid to the adjustment of radial thrust bearings and horizontal thrust ball bearings where excessively big or small clearances are inadmissible.

Felt packing rings must be impregnated with oil at a temperature of 80-90°C. Labyrinth packings must be filled with grease. In sliding bearings poured with babbitt, bronze, zinc- or aluminium-base alloys, the non-ferrous alloy must be reliably connected with the bearing which is achieved by mechanical fixing or by an adequate preparation of the surface for pouring. The reliable connection at pouring is checked by knocking.

Scraping must ensure an adherence of contact surfaces at which there will be at least five stains per cm^2. The cam and toothed couplings must be mounted so as to ensure a full meshing on their engagement. The clearance between the apex of the tooth on one gear and the tooth space on the other in radial direction should be equal to 0.25 of the pitch in cylindrical gears and to 0.2 pitch in conical gears. The accuracy of skew gears cutting must be additionally checked prior to the assembly. The smaller gear is fitted with a clearance on the shaft and is run around the greater gear. After the smaller gear has made a full revolution around the greater gear its axial position in respect to the greater gear is the same as before. The gears must run smoothly without jamming.

The transmission including the reducers must be run idle with oil filling. During running the noise must be regular without attenuation and increase; the packings and butt joints should not allow

oil leakage and the temperature of the oil in the frame should not exceed the ambient temperature more than by 40°C, while the temperatute of the frame should not exceed the ambient temperature by more than 30°C. Oil for running-in must be of the same brand and viscosity as the oil during operation, but with an addition of 5% of sulphofreesol. All the defects detected at running-in should be eliminated.

REVIEW QUESTIONS

1. How are the machines received for repairs?
2. What tools are used by the maintenance staff? What are they designed for?
3. Why are cleaning and washing of parts necessary and how they are carried out?
4. Discuss the inspection and sorting of parts and the instruments used for checking the part quality.
5. What kinds of shaft repairs do you know?
6. What is the essence of the repairs of worn-out shafts?
7. What is the aim and essence of shaft machining?
8. What are the methods employed for the restoration of bearings?
9. How are the bearings restored by pouring?
10. Name the machining methods used for the repair of bearings.
11. How are the gears repaired?
12. How is the equipment assembled after repair?

CHAPTER 5

REPAIR AND ADJUSTMENT OF THE EQUIPMENT IN THE SPINNING DEPARTMENT

1. Blowing Range

The blowing range consists of several blending feeders, the waste and head feeders, the feeding lattice, the horizontal and vertical openers, the high-speed condenser, the rake distributor and of several single-process scutchers.

To prepare the machines of the blowing ranges for repairs they are cleaned from waste and rests of raw materials.

Blending feeder. At the time of medium repairs the following operations are carried out in the following units:

feeding lattice—checking and replacing faulty balls, rollers, plates and belts;

spiked lattice—checking and replacing faulty bearings and plates, straightening and filing spikes, checking belts and the lattice;

evening lattice—checking and replacing the evening and side rollers, and of the lattice proper;

knock-off roller—checking and replacing faulty bearings, dressing of blades, cleaning of burrs, adjustment or replacement of the leather, checking the grid bars and setting the reach;

transmissions—checking and replacing faulty pulleys, tension pulleys (block wheels), shafts and bearings;

fan and lattice — checking and oiling the bearing, checking the drive, replacing faulty parts, checking and repairing the delivery lattice;

bracket with block wheels and the shaft of the riser—checking grid bars and grinding burrs, installation of grid bars according to the template, checking, cleaning and greasing of antifriction bearings, checking the lifting mechanism of the vertical shaft and replacing its faulty parts.

In addition to the aforementioned operations, the following jobs are done in overhaul repairs: checking and replacing faulty bearings of the feeding lattice, and if necessary replacing the lattice proper; checking the cylinders of the feeding mechanism and deburring of cylinders and journals; checking and replacing faulty bearings of the blade cylinder; checking the blades of the cylinder and grinding

the burrs, removing grid bars and deburring; checking the doffing knives and deburring, setting the reaches according to a template; dismantling and checking the regulator, cleaning the pedals with graphite, adjusting and checking the bevel drums for easy rotation and checking and replacing faulty bearings.

Single process scutcher. The following work is carried-out in the following units in the course of intermediate repairs:

feeding mechanism—checking and repairing the feeding lattice and the rollers, checking and repairing the feeding and pedal cylinders, deburring;

beater—opening the beater and disassembling the grid bars; elimination of burrs on the beater blades and grid bars; assembling the grid bars and setting the reaches of the beater and grid bars according to the template; repairing the mechanism for automatic locking; checking the beater bearings and replacing the grease.

pedal regulator—dismantling and checking the regulator, cleaning the knife-edge and pedals with graphite, adjustment of the belt shifter, checking for the easy rotation of bevel drums and replacement of worn-out bearings;

cages and grid bars—checking the cages and bearings, checking the fan bearings, the delivery roller and deburring, replacement of worn-out leather packings, removal of grid bars from the waste box and deburring;

front part of the cutter—disassembling and checking the calender rollers, the cut-off mechanism and lap winding mechanism; deburring the shafts and cleaning the bearings;

drive—checking and repairing of faulty parts in the drive and their replacement with new ones.

At capital repairs in addition to the aforementioned operations the following work is carried-out: removing and checking the bottom cages; replacing collars; disassembling the grid bars in the waste chambers, their straightening and cleaning; replacing and repairing evening and knock-off rollers; checking and repairing the transmissions and levers of treadle regulators; complete disassembly and repair of the knocking-off mechanism and transmission to the pedal cylinder; checking and repairing the bottom main shaft; removing, checking and balancing the knock-off roller in the reserve chamber, and checking the frames with a cord and a level.

At the disassembly, sorting, and repairs of parts, assembly and adjustment of the blowing range the admissible deviations and wear of working parts established at repairs are to be strictly followed.

The cage and fan. The main disarrangements in cages are: the opening of the longitudinal joint, the detachment of the cage from the rims, cage breakage in one or several points, the wear of tyres due to rubbing against other machine parts, and cracks in different points of the rims.

Cages with open longitudinal joints are repaired by resoldering or stitching with wire. Lately different kinds of mechanical jointing have been used by means of the net *1* (Fig. 45), the rings *2* and dowels *3*.

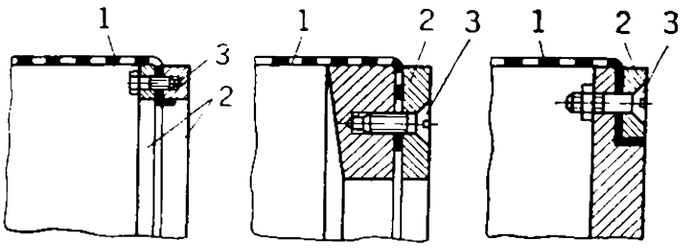


Fig. 45. Mechanical methods of fastening net on cage

A completely worn-out net is replaced by a new one: the net is fastened onto the rims by means of clips and soldered or mechanically attached in place. Figure 46 illustrates a machine for mechanical covering the cage with a net. The machine stand *5* carries two clamping cylinders *3*, the axle *4* with a strap for making clips, a manual gear drive *2* and the pressure carriage *1* displaced along the stand.

Patches are placed in separate points of the worn-out or broken net which are further interlaced and soldered.

For better convenience in disassembly and removal, the cages have a dismountable shaft. In single-process scutchers TO-18 first the cage bearings are inserted from the interior side of the frame, after which the cage and shaft are mounted onto them. The faulty rims of

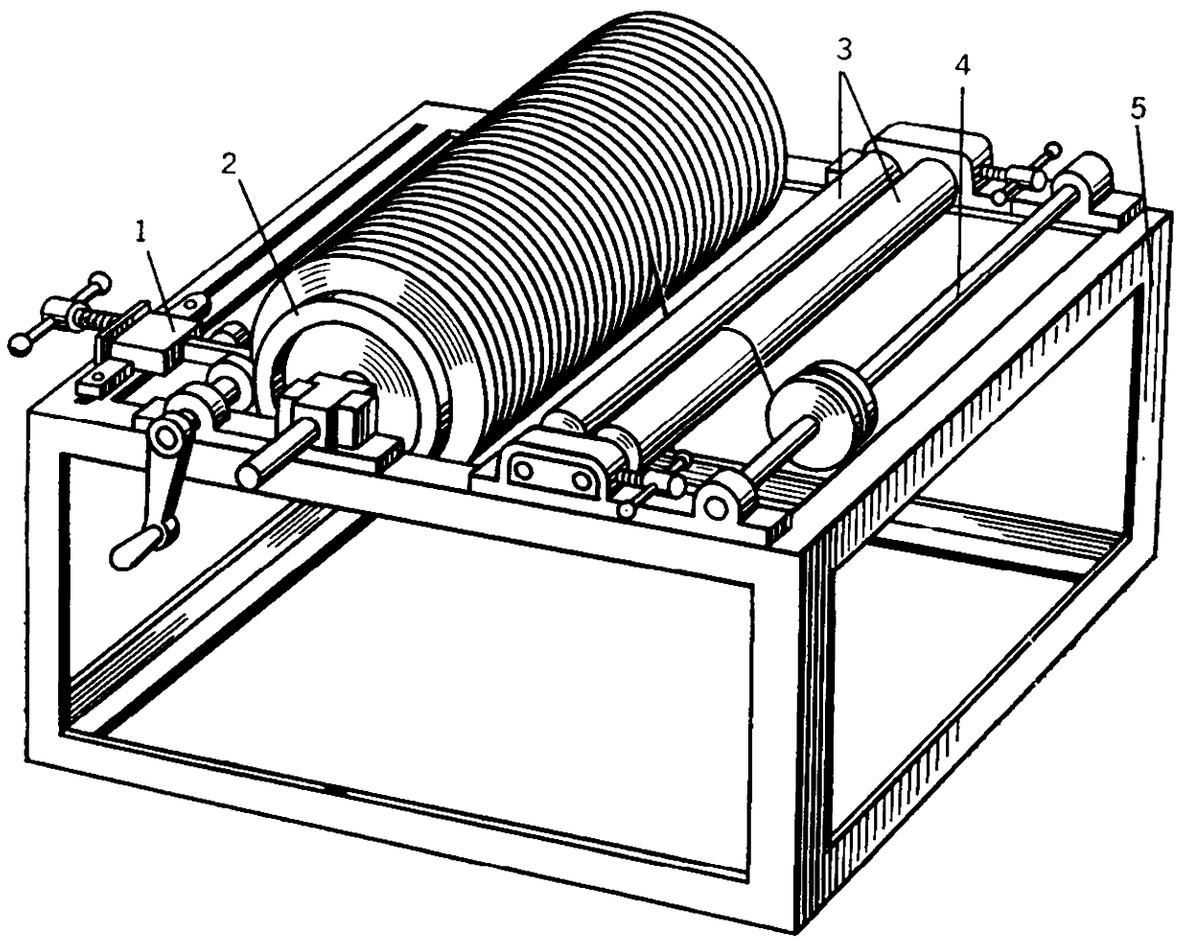


Fig. 46. Machine for covering cage with net

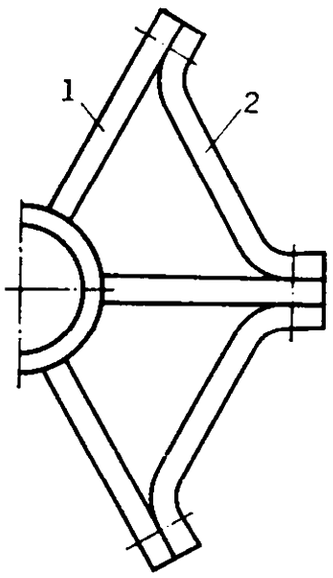


Fig. 47. Reinforcement of fan blades in single-process scutcher

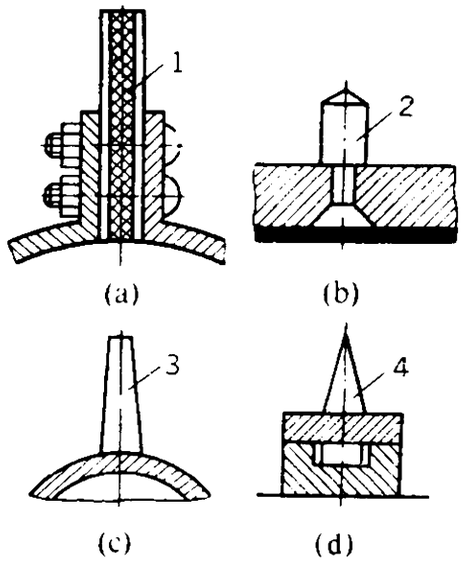


Fig. 48. Methods of attaching fillet on rollers of blowing range

the cage are repaired in the similar way as the belt drive pulleys.

For reducing the contamination of the net with fluff, trash and dust it is coated from inside and outside with spirit varnish so that the cage surface becomes smooth and there is no accumulation of fluff and dirt. Owing to this, the machine idle time is reduced and the quality of laps is improved.

The main disarrangement in the fan is the breakage of blades when they get loose from the shaft. The repair consists in welding the blades. To ensure a stronger fixing of fan blades, holes are drilled at their ends *1* (Fig. 47) after which the blades are tightened together by bolting with steel plates *2* (the mass of the plates must be the same). After the repairs, the fan rotor is balanced.

Rollers and beaters. In blowing scutchers, blade, doffer, cleaning, evening, and spiked rollers are used as well as blade and needle beaters. They are removed from the scutcher and mounted on it by means of a special crane-truck with a hoisting capacity up to 4 kN.

The blade roller gets out of order as a result of the deformation and the detachment of separate blades. At repairs the faulty blades are straightened according to the template and loose blades are riveted. Next, the screw space between the blades is checked and the roller is balanced.

The doffer roller consists of a steel shaft on which six steel rimmed sections are mounted. Between the rims leather blades are clamped which are liable to crack in service.

At the repair of doffers, the faulty blades are replaced with new ones made of rubberized belting. The leather or rubberized belt *1* (Fig. 48*a*) used for making blades must easily bend, but at the same time must be very rigid. Excessively soft blades will bend very qui-

ckly and will fail to reach the teeth of the spiked lattice, and on the contrary excessively rigid blades will knock against the teeth causing the slackening of the plate on the lattice. In the blade, V-shaped slots are cut out with a pitch corresponding to the pitch of the teeth on the spiked lattice or on the opening roller. This is made to ensure a better removal of fibre from the teeth of the spiked lattice.

Cleaning rollers are repaired in the same way as doffer rollers.

The evening roller is made of a steel shaft carrying three disks to which six steel blades with thick riveted-over needles are attached. In the course of the work the needles become loose and bent. At the time of repair, the faulty needles are cut-off and new needles *2* (Fig. 48*b*) are fixed in place.

The spiked roller is made of a steel pipe with flanges. The cylindrical part of the pipe has four rows of beveled spikes (the angle of inclination is 10°). When the spikes are deteriorated they are cut away, the point of cut is dressed and new spikes *3* (Fig. 48*c*) are arc-welded. The point of welding is filed or sand-papered.

The automatic bale feeder has seven spiked rollers. Each spiked roller has a shaft which carries disks and plates with spikes *4* (Fig. 48*d*) attached to these disks. Deteriorated spikes are replaced by new ones.

When repairing rollers of all kinds care should be taken that all spikes or needles are of the same height and the rollers have the same exterior diameter.

The blade beater is a shaft with cross-pieces carrying steel trapezoidal plates. These plates have a reserve edge so that at blunting (wear) of the working edge the plate may be turned round and the reserve edge is used as a working one. After both edges have been used, the plate is removed and machined on a planer (the angle of edge inclination is 75°). The edge should be well defined but not sharp and its plane must pass through the centre line of the beater shaft.

The restored blade *3* (Fig. 49) is attached on the spider *4* by means of a bevel screw *1* and locked with a dowel *2*. The point of fixing to the spokes is carefully finished.

After the repair or replacement of blades, the beater is subjected to balancing. If in this case, the blade must be made heavier, then building-up may be carried-out from the interior side of the blade. The width of the weld must be narrower than that of the blade back plane and must have an oval surface. If at balancing of a three-blade beater it appears that one blade is heavier than the other, it must be planed.

Modern scutchers are provided with saw-toothed or needle three-blade beaters, as smooth blade beaters do not ensure efficacious cleaning and separation of staples. The main deteriorations of saw-toothed and needles beaters observed in practice are due to the bending and

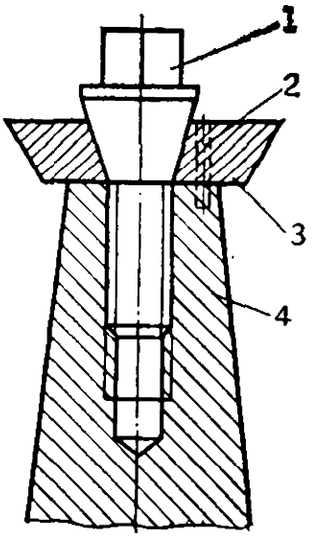


Fig. 49. Method of fixing blade on spider of three-blade beater

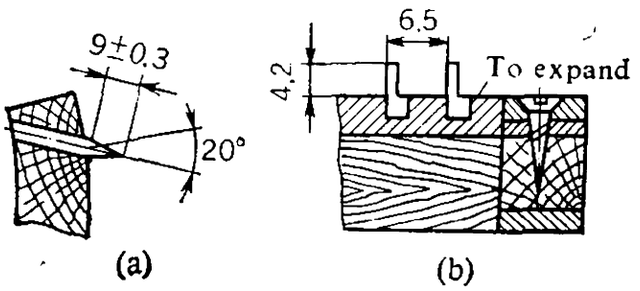


Fig. 50. Methods of fixing needles (*a*) and saw-toothed fillet (*b*) in the beater lags

breakage of teeth or needles. At the repair, the needle or saw-toothed lags are removed from the beater. If the needle or toothed covering is deteriorated by 25-30%, the lags are replaced by new ones.

The methods of fixing the needles and saw-toothed ribbon to the beater lags are shown in Fig. 50. At repairs, care should be taken that the wooden lags to which the needles are attached have no excessively high moisture content, no cracks and other defects. The needles must be set at the same angle and should protrude from the wooden lag at the same height. The points of the needles should be in the same plane which is eccentrically disposed relative to the center line of the beater (the front edge should be three or four millimetres closer to the axis than the rear one); the needle surface should be parallel to the axis of rotation.

At the replacement, the blades are chosen of suitable mass to avoid disbalance of the beater. Repaired beaters are balanced together with the attached fillet (a dynamical balancing is necessary).

Grid bars. During the operation of the grid bar (in conjunction with the doffing and blade rollers, and beaters), the grid bars are liable to deformation, their surface becomes clogged with fibre and burrs appear on it.

At the reparation of the machines and prior to their installation, the grid bars are carefully cleaned and bent bars are straightened, indentations and burrs are eliminated and they are polished. Straighting of grid bars in horizontal and vertical directions (along the faces) is made in a screw press. First, the indentations and burrs are eliminated by a rapidly rotating grinding wheel and next polished using a felt wheel impregnated with polishing paste. The working faces of the grid bars are set parallel to the beater with a deviation not in excess of 0.5 mm.

If pivotable grid bars are used, it is necessary to check that they should easily and simultaneously turn, the maximum angle being 30°. For inclined grid bars it is necessary to additionally check the good condition of the bottom cover and its tight fitting.

Pedal evener motion or pedal regulator. It consists of a feeding cylinder, pedals resting on a prism or roller, pedal pendants, links and cone drums.

During operation the feeding cylinder may be deformed and its journals and bearings may be worn. The feeding cylinder is straightened so that it is strictly rectilinear and has a constant diameter throughout the full length. The journals are restored by chromium plating or ground for obtaining the repair dimensions. Worn bearings are replaced by new ones. The journals and bearings are adjusted to avoid swinging in radial and axial directions, but so that the feeding cylinder may easily rotate in the bearings.

In the course of operation, small cracks and pits appear on the pedals and if their number is more than three or their diameter exceeds 3-4 mm, the pedal is replaced by a new one.

Considering that the fibre passes over the surface of the pedals, high requirements are set towards their quality. Small pits are soldered with tin and carefully smoothened. The surface profile of the pedals is worked strictly to the template. Wear of pedals should not exceed 1 mm, otherwise they should be replaced by new ones (the whole set should be replaced at once). The side surfaces of the pedals should have no ledges and cavities are soldered with tin. The total width of pedals should be 2 mm less than the machine width. It is necessary to keep under observation the uniform and tight adherence of the pedals to the cylinders (the clearance should not exceed 0.2-0.4 mm). The maximum stroke of the pedals (their lowering) in respect to the feeding cylinder should not be under 12 mm.

The pedals rest on a prism which must be strictly rectilinear and should have no surface indentations and other defects. The bent prism is dressed and, if damaged, soldered with tin. Prior to its installation the prism is carefully checked by the template (Fig. 51), cleaned and wiped with graphite. The template consists of a metal plate *2* with a shackle *4* and foot *5*. The templates are attached on the feeding cylinders *3* using the plumb bob *1*. If the depression on the foot accurately rests on the prism *6* it means that the latter is set properly.

All the system of pedal pendants, links and levers is checked for proper mating and mobility of joints. If the joints are worn more than 0.3 mm, the parts should be replaced.

The bevel drums shafts may be bent in operation. They are straightened on a press machine or by means of a crank. A level is used for the installation of rollers. The drums are balanced so that they can be out of true not more than 0.2 mm.

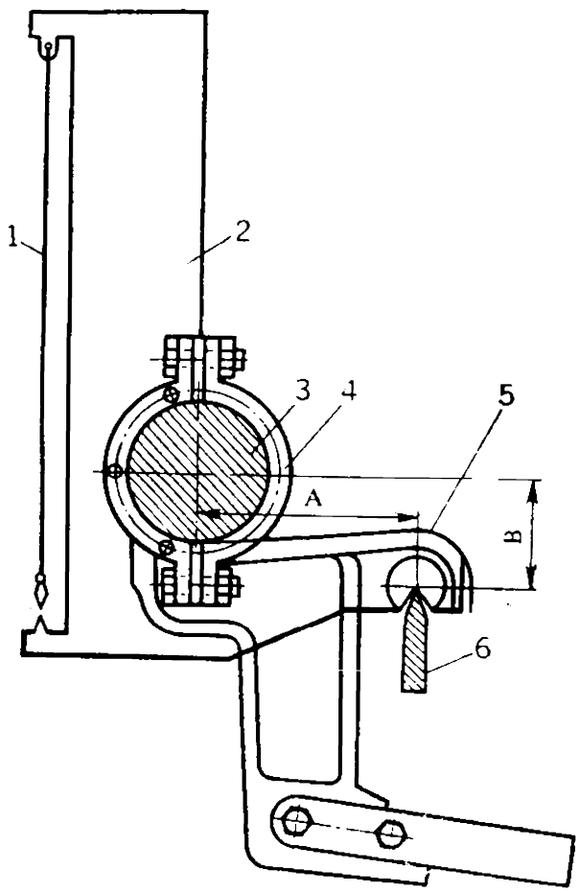


Fig. 51. Template for installation of pedal prism in single-process scutcher

Assembly and adjustment of the blowing range. At the assembly of the blending feeders and head feeders, all spiked and transport lattices must be disposed symmetrically relative to the machine centre line and should not catch its side walls. The same concerns the roller, beaters, calender and lapping rollers and cages. Sagging of the lattice and falling-out of the fibre are not allowed. The blades must be reliably fixed to the belts. The evening roller is installed according to a level and the roller teeth must be in the middle of the space between the spikes of the lattice. The leather covering the cleaning and doffing rollers should not catch the lattice spikes. The blade roller must be set strictly horizontally (according to a level) and must be properly balanced. Deteriorated (bent) grid bars are not to be put in place and only polished grid bars may be installed.

At the assembly of horizontal (porcupine) and vertical openers using a level, rule and feeler it is necessary to see that the stand is strictly horizontal. The surface of parts coming in contact with the fibre must be carefully cleaned with sandpaper, polished with chalk and wiped with graphite. Special attention should be paid to the checking of reliability of fixtures and to the proper disposition of the working face of blades. The blade roller is set strictly horizontal with a level and balance (the roller must be easily rotated by hand). There must be no air suction between the wall of the stand and the face of the cage.

At the assembly of a single-process scutcher using a lever, rule and feeler the stand is checked for horizontality. The blade rollers, heaters, calender and lapping rollers as well as cages are installed symmetrically in respect to the centre line of the scutcher so that they do not catch its side wall. All the surfaces of parts coming in contact with the fibre, are cleaned with an abrasive paper, and wiped with chalk and graphite. At time of adjusting of the blowing range it is necessary to adhere to the allowable deviations or wear of working parts established in the course of repairs.

2. Cards

The production of modern cards manufactured in the USSR is 10-40 kg/h.

The card consists of the feeding arrangement, the main cylinder and doffer, the flats, the doffing comb, the transmissions and the coiler. Prior to putting the cards in repairs, the wastes are eliminated, the card is dedusted and cleaned. At the time of intermediate repairs of cards the following work is performed in the following units:

the feeding arrangements—the back part of the card is disassembled, the taker-in cylinder is removed, the saw-toothed band is repaired and deburred. The taker-in bearings are dismantled and they are checked for good condition. The flanges are deburred and fastenings are checked, the grid bars are removed and restored, and the burrs on the receiving table are ground. The bearings and journals of the feeding cylinder are checked and deburred, the mote knives are examined, and it is ascertained that the taker-in and lattices are in proper condition;

the main cylinder and the doffer—the condition of the card fillet (whole-metal saw-toothed fillet or needle fillet) is checked, and if necessary it is brought in good working condition, the doffer and main cylinder bearings are opened and examined, the grease replaced, the pulleys are examined and repaired as well as the brackets for the grinding roller, the front and back knives and the lattice grid bars;

the flats—the set of flats is disassembled, the flats are replaced, and if necessary the flats cleaning comb and shaft are repaired;

the doffing comb mechanism—the comb box, the shaft journal and the doffing comb bearings are examined, the comb teeth are dressed and cleaned, the box is washed and filled with oil;

the transmission—the entire system of transmission is checked and repaired with replacement of worn-out gears and spindles;

the coiler—the wheel gear is removed after which the transmission is disassembled, checked and repaired as well as the calender rollers, can rotating tables and covers.

At the time of intermediate repairs, if necessary, the maintenance personnel shall check and repair the following units: the braking arrangement for the automatic interlocking of the main cylinder front cover, the mechanical or electrical stop of the card, and of the lubrication system, and the anti-friction bearings are cleaned. Then general lubrication, adjustment and running-in of the card are carried out.

At capital repairs in addition to the aforementioned operations much complementary work is done, i.e. the comb box and coiler are disassembled and completely repaired; the elastic bows and set bolts are removed, checked and put in place; the main cylinder and doffer are raised and the shells of their bearings are disassembled,

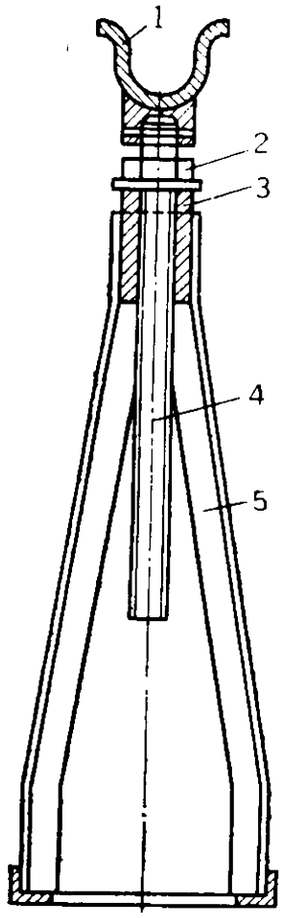


Fig. 52. Jack for lifting main cylinders of cards

washed, and put in place; the machine stand and coiler are checked with a level, cords and rules; the fillet on the cylinders and flats are replaced according to schedule.

The licker-in, main cylinder and doffer. Cards have a licker-in, a main cylinder and a doffer — all of big dimensions and mass. Each of them is made of a hollow cast-iron or steel cylinder (shell), crosspieces and a shaft attached in them. The main cylinder and doffer are covered with a fillet and with their shaft journals rest in antifriction bearings (in old cards in sliding bearings).

In the course of operation various disarrangements occur such as notches on the journals, slackening of the shaft attachment in the crosspieces, running out of true, deterioration of the taker-in side plates, pulleys, couplings and others.

Lifting, removal and transport of the licker-in, main cylinder and doffer for repairing in the shop as well as their transport and installation after repair are rather complicated and heavy, and require special jigs and fixtures. For this reason, it is more convenient to carry out these repairs directly on the card using for this aim the jacks illustrated in Figure 52. The jack has a stand *5* welded of angles. Welded to the stand is the nut *3* in which the power transmission screw *4* with a trapezoidal thread is accommodated. The screw has a shackle *1* freely arranged on its end and on which the shaft end is bearing. The screw *4* has a hexahedron *2* for raising and lowering the screw with the aid of a wrench. The licker-in or any other cylinder is raised by uniformly screwing-in the power transmission screw (the flexible bows of the card need not be set apart). Different operations (dimension control, building-up, fixing of repair bushings, replacement and repairs of bearings and others) may be carried out on the cylinder after raising it by means of jack.

If the antifriction bearing is out of order the shaft of the taker-in, main cylinder or doffer comes also out of order. In this case, the bearing is replaced by a new one for which the shaft is turned, a split bearing is fitted on the shaft and over it an antifriction bearing preliminarily heated to a temperature of 70-90°C (in mineral oil).

The device for turning the said shaft on the card (Fig. 53*a*) has a base *1* which is fixed instead of the removed bearing shell. The shaft rests on a temporary split bearing *2* mounted on the base shelf. The

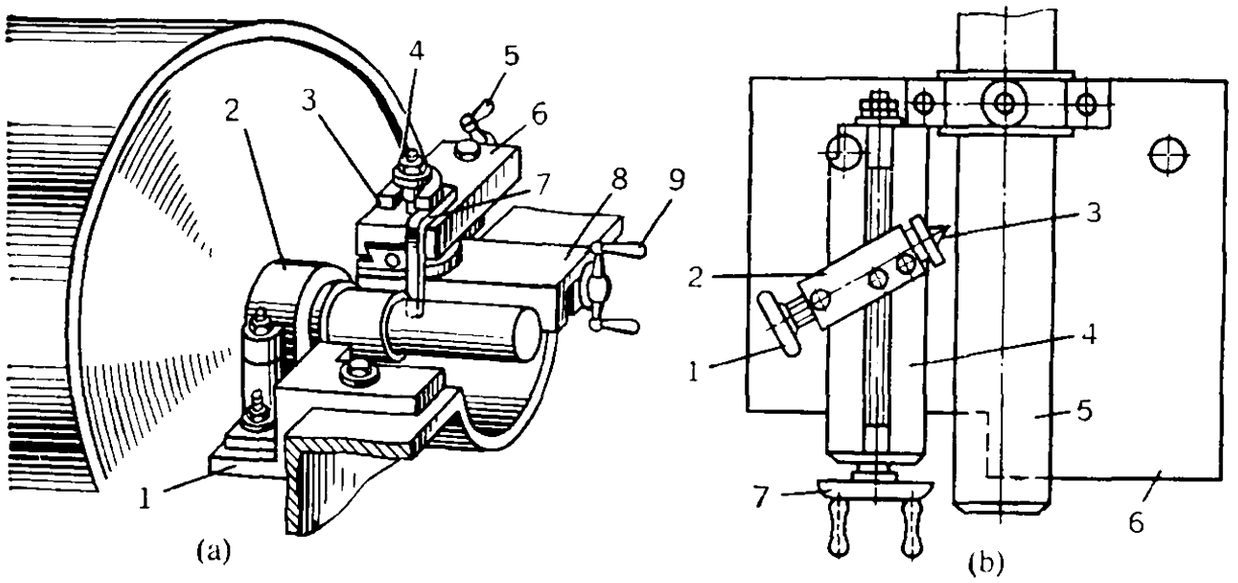


Fig. 53. Device for turning main cylinder (*a*) and doffer (*b*) on **card**

device has a slide rest with top carriage *6* and bottom carriage *8* each of which has its own screws *5* and *9*. The top carriage ensures the cross motion; and the bottom carriage — the longitudinal movement of the cutter *7* (relative to the shaft to be ground). The cutter *7* of bent shape is attached according to the shaft centre by the plate *3* with the bolt *4*. The device is mounted using the template and taking care that the axis of bottom carriage movement is parallel to the axis of the shaft to be turned. On shaft turning, the adequate cylinder is brought in rotation by a driving belt running on the pulley at the opposite end of the shaft.

When turning the shaft of the doffer a special device is used (Fig. 53*b*). Attached on the plate *6* is the slide *4* travelling on which is the holder *2* with the cutter *3*. Using the screw *1* the cutter is brought to the rotating shaft *5* while the screw *7* serves for the longitudinal feed.

In the course of operation, the holes of the main cylinder may get worn-out at the place of the keyed joint of the shaft with crosspieces due to which the reach between the main cylinder and the cleaners is impaired, and the run-out of the main drum and its disbalance are increased.

The holes are restored by means of a boring bar (Fig. 54) ensuring their coaxiality. The supports and guides of the boring bar *2* are made as bronze bushings *7*, pressure fitted in two crossheads *8* which are mounted over the exterior diameter of the main cylinder *9* with close fit; the crossheads are attached on the main cylinder by means of ties. The boring tools are put in the through sockets of the boring bar, which carries also reamers *3* for hole finishing. One end of the boring bar is connected (by thread) with the nut of the clip *1* attached to the crosshead. Using the crank *6*, the main cylinder is displa-

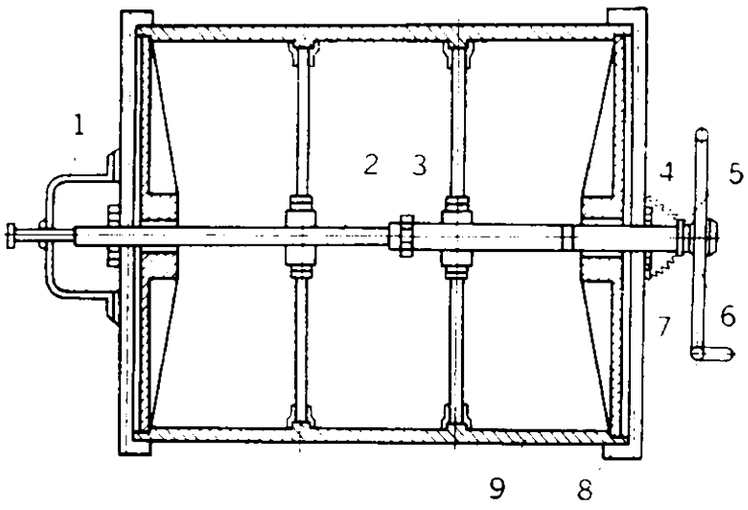


Fig. 54. Boring bar for cylinder boring

ced in axial direction. The radial effort at boring is taken-up by the crosshead bearings while the axial effort—by the thrust ring *5* connected with the crosshead by three springs *4*. After boring is finished, a new shaft is inserted into the main cylinder and fixed in place. The assembled cylinder is subjected first to static and then to dynamic balancing. The cause of the short service life of sliding bearings (bushings) is unreliable lubrication. In order to ensure a reliable feed of lubricant into the bushing from the inside and all over the length, a helical groove is provided and at the end, at the lubrication hole, a deep recess is made through which the oil can freely enter and may be properly distributed.

During card repair, the sliding bearings are frequently replaced by antifriction bearings. For this, the bearing shell is extended and a cover is made which is attached with several screws.

In the course of operation the bushings of the licker-in side plates are gradually worn-out due to which the reaches between the taker-in and feeding table, the main cylinder grid bars and knives are impaired. At the time of repair, the side plate with a worn-out bushing is replaced by a new or restored one. The worn-out bush is cut off and in the side plate a recess is bored into which a new bushing is pressure-fitted and tightened with four dowels.

Covering with card fillet. In cards the main cylinders and doffers are covered with a whole-metal saw-toothed or needle fillet, while the licker-ins are covered with a saw-toothed fillet. The cleaners and workers are also covered with a whole-metal fillet.

After the elimination of the old fillet, the licker-in, main cylinder and doffer are ground on movable grinders and then covered with a new fillet. Grinding is done to impart the cylinder surface a regular cylindrical shape. The speed of the grinding wheel is 10 m s^{-1}. After grinding the cylinders are checked for run-out at the ends and

in the middle by means of a watch-type indicator; the run-out should not exceed 0.05 mm.

After this, the cylindricity is checked. For this, the circumferential length from each side face of the cylinder is divided into the same number of lengths and the marked-out points are connected along the generatrices. A metal rule is placed with its edge on these lines and the clearance between it and the cylinder is measured by a feeler (the clearance should not exceed 0.04 mm).

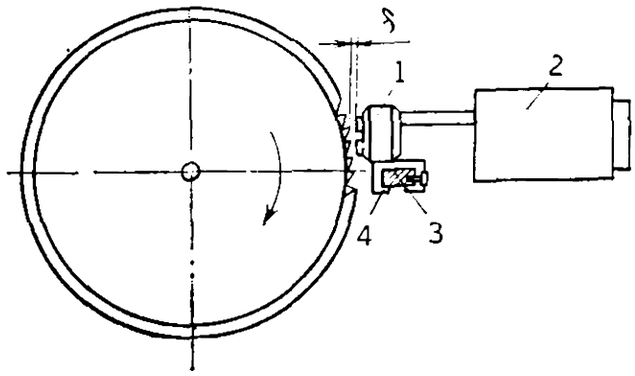


Fig. 55. Diagram of device with variable induction pick-up for determining dynamic parameters of card cylinders operation
1—pickup; *2*—oscillograph; *3*—guide; *4*—slider

The cylinders are covered with a whole-metal saw-toothed fillet by means of special units (for instance the fillet covering unit ПО-1).

One of the main causes of reach violation, resulting in the deterioration of the fillet, is the irregular deformation of the cylinders. A strong cylinder deformation may be due to the heating of the saw-toothed fillet at covering and further at its cooling on the cylinder shell. The proper position of the saw-toothed fillet on the cylinder depends on the tension applied in covering.

The process of card cylinder covering with whole metal saw-toothed fillet has been considerably improved and stabilized by the modernization of the fillet covering unit ПО-1 and the incorporation of a shoe-brake at the fillet holder, the elimination of front pressure rollers and the incorporation of rollers effecting the preliminary bending of the fillet, the use of a compressing blade in the shape of a moving roller and the use of a stationary drive.

The doffers are also covered with a whole-metal saw-toothed fillet at a variable tension of the fillet in the unit ПО-1.

To determine the dynamic parameters of the card cylinders in practice, instruments are used with an electromagnetic parametrical system in which the cylinder acts as a core (Fig. 55). With a change in the air gap δ between the core and the bobbin (i.e. with some impairment in the surface of the cylinder covered with a whole-metal saw-toothed fillet) the inductivity of the bobbin is modified which is immediately recorded by an oscillograph. In this way, it is possible to determine the reaches between the main cylinder and the flats.

A new method has been elaborated for the operative control of reaches between the fillets of the card working organs both at halts and in operation. Plates 5-12 mm in diameter and 3 to 5 mm in thickness of a material with high plasticity (ceresin or paraffin) are used as recording elements. These plates *4* (Fig. 56*a*) are fixed on

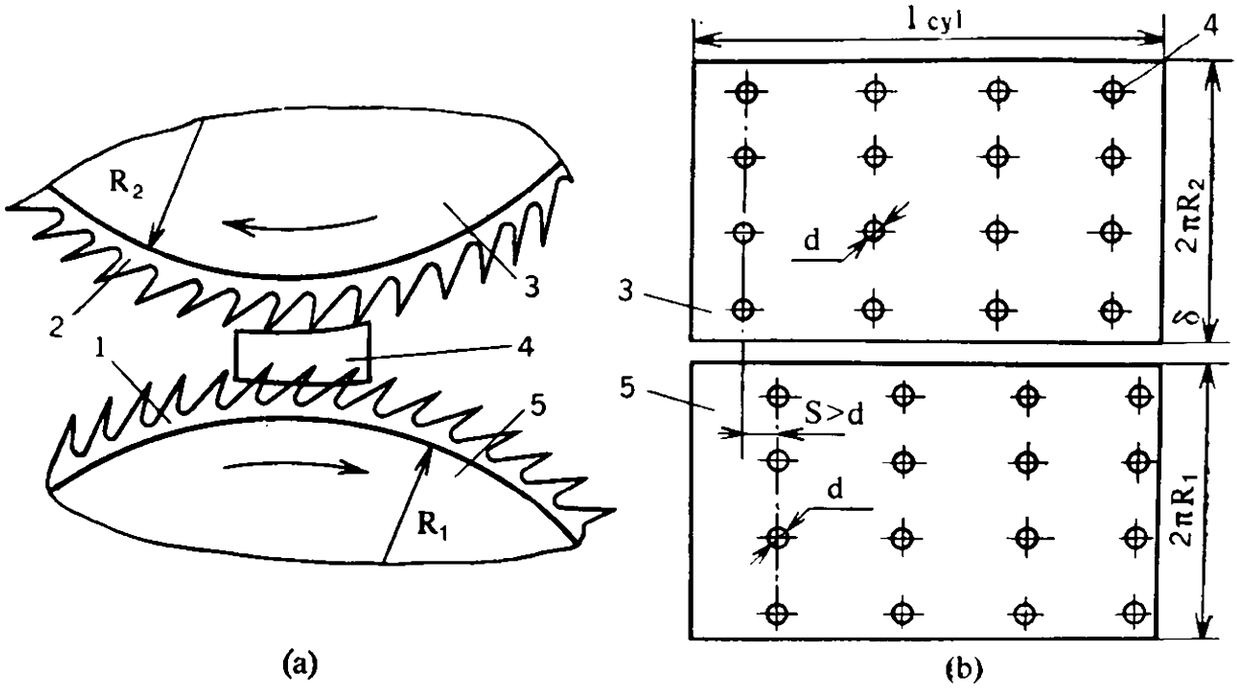


Fig. 56. Mounting control plates on card fillet
a—fastening control plates on fillet; *b*—position of control plates on cylinder

the fillets *1* and *2* of mating carding surfaces of the cylinders *3* and *5*. Plates from 12 to 16 mm in diameter are used on the taker-in with a fillet of coarser pitch. Each plate is immersed with the index finger into the fillet; however to avoid the collision between the plates disposed on mating cylinders, the plates are shifted apart to magnitude *S* (Fig. 56*b*) which is by 10-12 mm greater than the plate diameter.

When checking the reaches on a machine at standstill, the working organs are manually turned for 15-20 s, and in checking the reaches on a working machine—for several seconds. Further, the working organs are stopped and, using the device illustrated in Fig. 57, measure the height of the plate layer protruding above the fillet, which has not been removed by the fillet of the other cylinder. The device is placed on the fillet *5* of the working organ so as to bring the centre of the plate *1* in coincidence with the measuring tip *4*. The readings are taken using the indicator *2* mounted on the base *3* with two bearing platforms. These measurements allow the determination of cylinder run-out and the reach between them. This method ensures a better quality repair

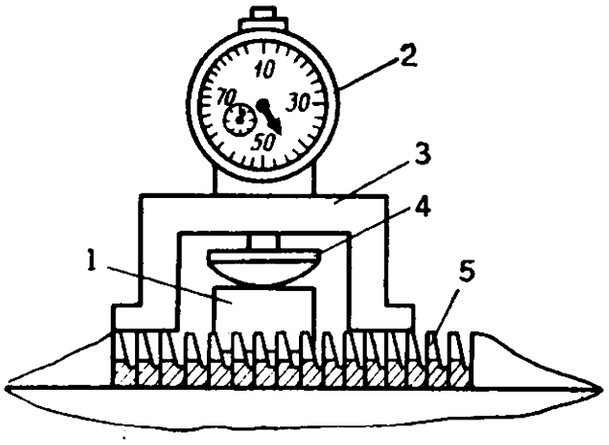


Fig. 57. Device for checking reaches on card

and requires less time for checking the reaches and for the repairs. The errors in the control of reaches under the dynamic and static conditions of the machine and in checking the cylinder run-out do not exceed ±0.005 mm.

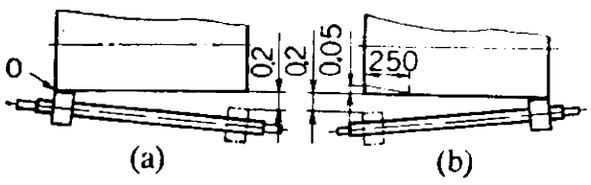


Fig. 58. Diagram of cylinder installation in end bevelling
a—cylinder left end; *b*—cylinder right end

When preparing the main cylinders and doffers for covering with saw-toothed fillet, it is recommended to grind the shell edges with beveling. In this way it is possible to ensure the rectilinearity of the cylinder saw-toothed surface generatrix after its covering with a whole metal saw-toothed fillet. For example, when covering the main cylinder with saw-toothed fillet, its ends are ground by an amount of 0.05 mm over a length of 250 mm. Figure 58 shows how the grinder is installed at the generatrix of the main cylinder. The bevel surface of the cylinder ends is obtained by the parallel feed of the cutting wheel using the adjusting screws from both sides of the grinder. Beveling of the cylinder may also be achieved with the aid of a special cutter.

After covering the cylinder with fillet the evenness and run-out of its toothed surface is checked. The evenness of the covering along the generatrices is checked by means of a rule and feeler, while the run-out is checked by a special instrument operating on the contactless principle.

If the fillet teeth are of different height, the protruding teeth are machined with a needle file, while bent teeth are straightened by a grinder. For levelling the surface the filleted cylinders are ground.

Further balancing is carried out, i.e. the licker-in and the doffer are subjected to static balancing, while the main cylinder is dynamically balanced. The static balance of the doffer is checked by turning it in its proper bearings from which the lubricant has been preliminarily removed. In doing so, the heavy weight points causing the disbalance are detected. The doffer is balanced by means of weights fixed to attachments: the doffer comes out of balance when a weight of not more than 50 g is tangentially attached to it.

The licker-in is subjected to static balancing on knife edges by attaching the balancing weight to its bottoms; a balanced licker-in is disbalanced when a weight up to 30 g is attached to it.

The dynamic balance of the main cylinder is checked in its proper bearings in the card with the main shaft rotating at the working speed, and dynamic balancing is effected on each of the machine stands in alternating order using a low-frequency balancing arrangement. The device (Fig. 59) is provided with two similar converters having their sensors *1* and *2* attached to the bearing shells. The source of bearing oscillations is the main cylinder *4* which is not balanced at the working rotational speed. The device has a stroboscopic lamp *3*

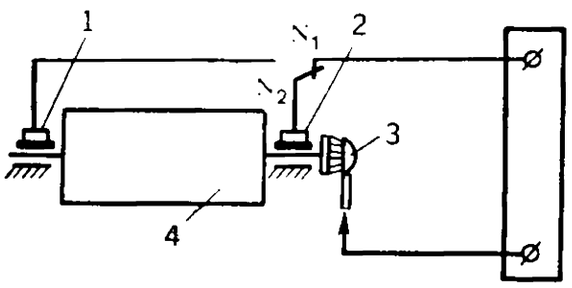


Fig. 59. Diagram of device for balancing card cylinders

one flash of which corresponds to each revolution of the main cylinder *4*. The balancing weight is determined by placing test weights. For instance, it is sufficient to reduce the disbalance of the main cylinder to 250 g/cm in each plane, which corresponds to the vibration shift of 0.008-0.01 mm.

Pulley and friction clutch. The pulley and friction clutch (Fig. 60*a*) are comprised in the main cylinder unit and may be subject to different disarrangements in the course of operation: the bushing *6* turns and causes the wear of the main cylinder shaft *7*; the fingers of the driving hub as well as the holes of the friction clutch hub get worn out; the steel disks are torn off. In the first case, the bushing is replaced by a new one and the key *5* is made 12-15 mm longer. In the second case, the worn-out hole is reamed and a new finger is made to suit the new dimension of the hole. The torn-off disk *2* is replaced by a new one which must be perpendicular to the coupling centre line and must ensure a good mating with the other disk.

For increasing the service life of the finger *3* another fixture is used in the driving hub *1* (it is fixed with a nut instead of pressure fitting). A hole with a diameter up to 25 mm is drilled in the hub of the friction clutch *8* and a polyvinylchloride or rubber bushing *4*

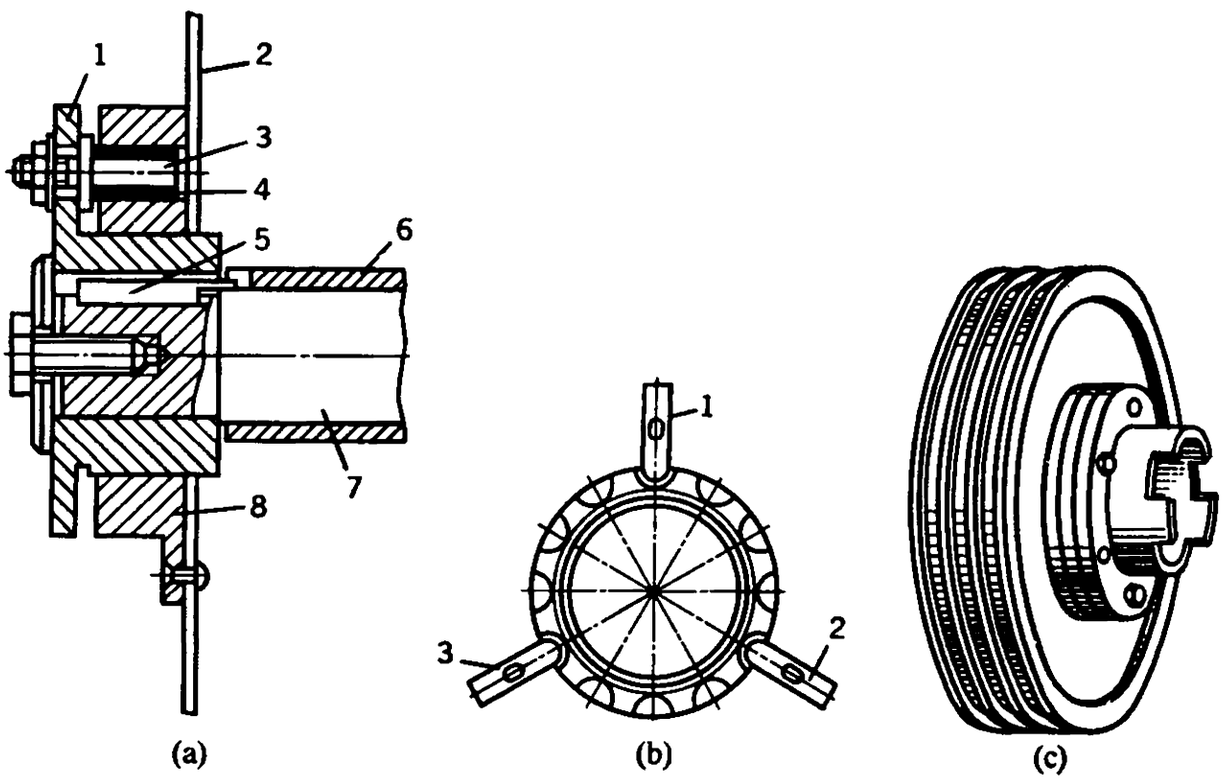


Fig. 60. Pulley and friction clutch of card cylinder unit

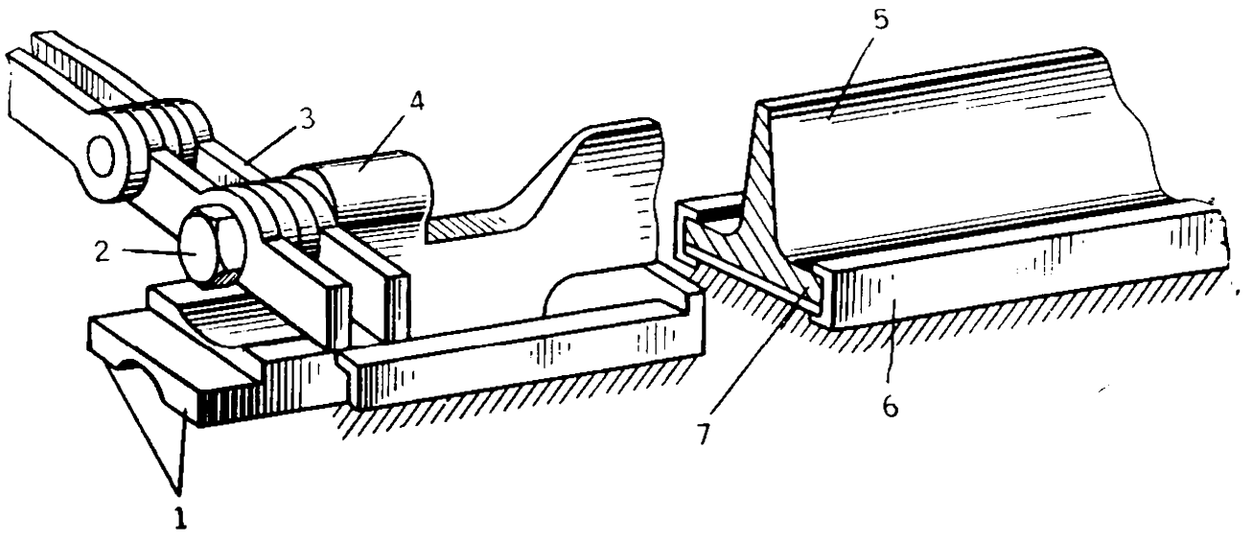


Fig. 61. Card flat

is fitted on the finger for attenuating the impacts at the engagement and disengagement of the friction clutch.

In the card friction clutch the socket, pressure levers and small wheel block are frequently worn-out. The worn-out socket and small wheel block are replaced by new ones at the time of repairs. In order to increase their life, the sockets are made with twelve alveoluses (instead of three ones as in the previous sockets) which allows the use of the socket four times without removal and disassembly of the friction clutch (Fig. 60*b*). To ensure a better reliability of the clutch fixture, three bolts (or every other of the six bolts used) are replaced with pins *1-3* of greater diameter which safely counteract the shearing efforts created at machine starting (Fig. 60*c*).

In the doffer engagement clutch the wheel block keyway gets worn out. During repairs a worn-out keyway is replaced by a bronze bushing (of the same dimensions as the key) which is then welded, and the weld is machined. Owing to this it is possible to avoid the wear of the keyway in the clutch of the doffer.

Flats. The main kinds of disarrangements which are observed in flats are the wear and warping of the needle fillet. The flat (Fig. 61) consists of a cast-iron bar *5*, the flat needle fillet *7* and the clips *6* by means of which the flat set is attached to the bar. At each end of the bar, there is a boss *4* with a hole for connecting with the chain of flats. The bolt *2* which serves simultaneously as the axle of the chain member passes through the chain plates and the hole in the boss of the bar. At the left and right ends of the bar there are well-finished shoulders *1* by means of which the flat rests on the flexible bows.

The worn-out needle fillet is stripped from the bar on a special machine (Fig. 62). Using this machine the worn-out fillet is stripped from seven bars at a time. The flats *3* are attached on the base *5*

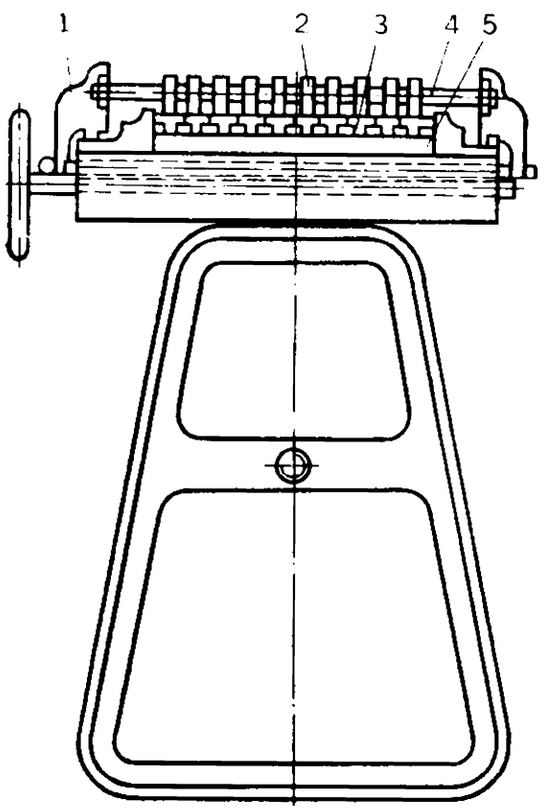


Fig. 62. Machine for stripping fillet from card flats

having guides for the carriage *1* on its ends. Fixed on the carriage are the holder *4* and strippers *2* which at the carriage movement strip the worn-out fillet from the flats. There are also machines for stripping the worn-out fillet with a blade. The production capacity of such machines is 40 flats per hour.

In modern cards the reach between the flats and the cylinder is 0.12-0.15 mm and with the use of a semirigid flat fillet in combination with a whole-metal saw-toothed fillet the reach is 0.1 mm. Under the action of their own weight the flats are liable to bending to 0.088-0.1 mm. For this reason strict requirements are set towards the shelf of the bar on which the middle fillet is attached: it must be smooth (7th class of finish) and with high planeness. The difference in dimensions in a set of flats should not exceed ± 0.025 mm. In the course of operation flat warping is possible, i.e. their planeness is impaired, residual bends up to 1.5-2 mm appear, as well as other defects. In case of warping, a flexible fillet is straightened by grinding (however it leads to a shorter life of fillet needles due to their wear). When semirigid fillets are employed no grinding is effected. Warped bars are straightened by cold dressing prior to being covered with a needle fillet. This is carried out in a special dressing machine. Owing to cold dressing it is possible to reduce the residual bend of bars to 0.1 mm The employment of semirigid flat fillet in modern cards has resulted in stricter requirements towards the precision of bar finishing (up to ± 0.025 mm). This proved necessary for the reason that after the semirigid flat fillet has been attached to the bar the needle ends are not to be ground.

To accommodate a semirigid needle fillet the surface of the flat bar is levelled as follows. A layer of polymer material is applied on the surface, and if necessary this new surface is levelled after which the needle fillet is fixed upon it (the use of this method is resorted to because after planing, milling or grinding for levelling the cast-iron bar surface the bars become warped).

The bars with worn-out flats are subjected to building-up with metal by gas or electric arc welding, or with polymer material (for

instance, styracryl) in moulds after which they are milled and ground.

The bars are covered with fillet in a special machine. The needle fillet with clips is brought over the bar base, the clips are inserted in the machine jaws and the flat base is pressed from the sides by special screws. From the top the needle fillet is held in special clamps. After tight clamping the needle fillet as described above, the clips are bent from both sides of the flat by passing pressure rollers several times along the fillet length. The rollers are arranged in the machine bending head. The clips are rolled up in one to-and-fro stroke of the head (Fig. 63). In the straight stroke *I* of the head the rollers are bent (item *1*) and further the clips are turned-in (item *2*) and in the reverse stroke *II* they are rolled up (item *3*). The reverse motion of the head is effected either automatically from a motor or from a hand drive.

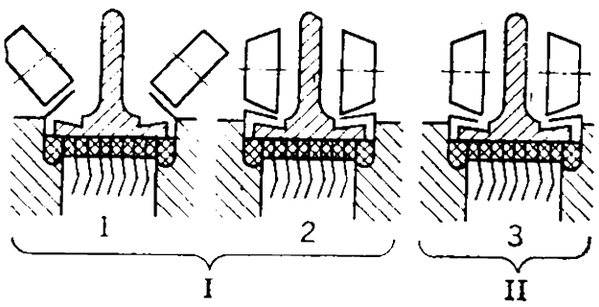


Fig. 63. Order of operations in flat covering

Rolling-up of clips must be tight over the whole length of the flats and should be without cracks, folds and burrs. The clip ends are centre-punched according to the flat recesses. The assembled flats are put in a set according to the height of elastic needles and sent for grinding the needle surface in special automatic machines with a production capacity of about 20 flats per hour (for grinding the needle covering to about 0.1 mm). To avoid the deterioration of the flat needle covering at their transport from the carding room to the grinding shop and back, special trucks with shelves are used.

Doffing comb mechanism. It consists of a comb made as a shaft *2* (Fig. 64) with pokers *4*, the comb box *1* and the bearing *3*. The main function of the doffing comb is the doffing of a thin layer of web from the surface of the doffer.

In modern cards the doffing comb performs up to 1900 oscil-

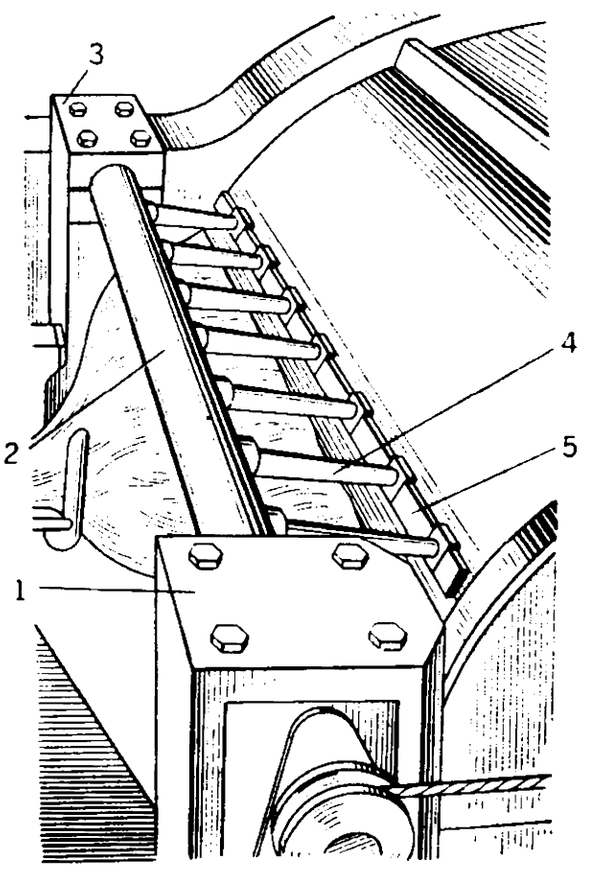


Fig. 64. Doffing comb mechanism

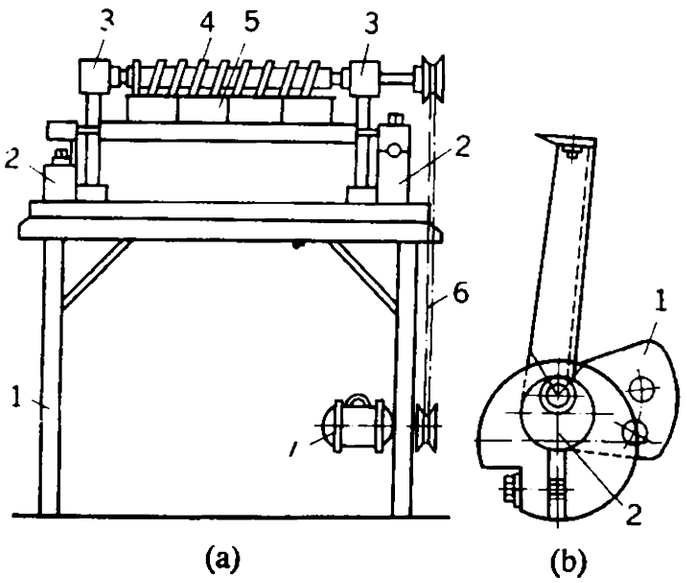


Fig. 65. Device for repair of doffing combs

lations or nips per minute. During the work the following disarrangements are sometimes observed in the comb: the poker fixture in the shaft holes as well as the steel toothed plates *5* on the pokers get slack; burrs appear on the toothed fillet of the plates; the shaft journal is worn out, etc.

At the time of repairs the slackened points are riveted once again. The worn-out journal is built-up by metal or chromium plating with subsequent grinding. The pokers of the doffing combs made of whole-drawn pipes are liable to deformation and breakage. In this case they are replaced with tubes of smaller diameter.

Burrs on the doffing combs are manually eliminated (by a needle file and wooden blocks) or by means of different mechanical means. One such device is shown in Fig. 65*a*. Fixed on the stand *1* are two posts *3* with bearings housing the journal of the polishing roller *4* (covered with a card fillet). The comb to be polished *5* is fixed on two other posts *2*. Care should be taken that on roller rotation the teeth are not damaged and only the burrs are removed. The roller is brought in rotation by the motor *7* through a V-belt drive *6*. The doffing combs may abso be polished by an electrochemical method.

After the repairs the doffing comb is subjected to static balancing. At this, in the parts made heavy the excessive metal is removed by drilling and at light points the metal is built-up by welding or soldering. The most progressive method is the use of a balancing washer (Fig. 65*b*). The properly balanced position of the comb is determined by shifting the washer *1* along the circumference of the shaft *2*. In this position a matchmark is cut on the shaft butt and on the balancing washer. A properly balanced comb works smoother and reduces the run-out in bearings and in the comb box.

After repairs the doffing comb is assembled and set so that its teeth are disposed parallel to the generatrix of the doffer surface. For this, the teeth ends must be set parallel to the shaft journals by means of special devices.

The harmful effect of inertia loads exerted on the doffing comb can be reduced by decreasing the weight of the comb and its shaft (which can be tubular instead of solid) and also by reducing the frequency of comb nips. However, the most efficient is the progressive

use of a new principle of comb motion, i.e. the use of roller doffing.

The comb boxes in cards of earlier design are with a link mechanism, while in modern cards an articulated four-member mechanism is used. Comb boxes of the first type are with sliding bearings, while those of the second type are with antifriction bearings.

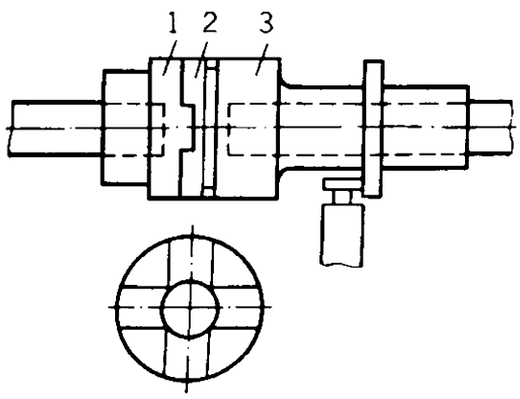


Fig. 66. Jaw clutch

During the operation of a comb box, the carriers, cranks, bearings, carrier sliders, crank bushings and other parts are worn out. At the repairs of an articulated four-member comb box, it is disassembled, cleaned, washed, the worn-out bearings are replaced, assembled, filled with lubricant and run-in. The link comb box is repaired by disassembly and assembly with faulty parts replaced by new good ones.

Calender mechanism and coiler. The calendering mechanism is intended for transforming the web into a sliver with its condensing. The calender rollers are mounted in sliding bearings with cast-iron bushes which are worn-out in the course of operation. The roller journals are also worn-out. The worn-out bushings are replaced with new ones and the journals are built-up with a steel layer (by welding or metal coating) and ground to the required dimensions. The use of bushings made of polymer materials, as for instance of capron (instead of cast iron), in the calender mechanism increases their service life.

When the calender rolls are worn out they are either replaced by new ones or repaired, i.e. the worn out surface of the roll is ground and a steel jacket is fitted-on in hot condition. To avoid damaging of the roll end at the time of fitting and removal of calender rolls and not to impair the fitting it is recommended to use a pipe and to knock against it with a wooden or copper hammer.

The calender rolls are put in motion by a jaw coupling. This coupling usually consists of two half-couplings *3* and *1* (Fig. 66) and an intermediate bush *2* connected by flanges. Such half-couplings get rapidly worn out at the points of contact with the intermediate bush (made of steel or cast-iron). At the repair the worn-out lugs are built-up, ground and adjusted to suit the recess. For increasing the longevity of the intermediate bush it is made of capron. This increases its damping capacity and the reliability of the whole driving unit is improved.

The card coiler serves for coiling the sliver in the can and for its condensing. The coiler has a couple of calender rollers resting in

cast-iron bearings. The supporting surfaces of the shafts and bearings are worn out in the course of operation. At repairs, worn-out bearings are replaced by new ones, and the supporting surfaces of the shafts depending on the amount of wear are built-up by chromium plating or metal coating.

There is a new more improved method of repair which is carried out as follows. The supporting part of the shafts is ground to remove the traces of wear and to impart it a regular shape; then it is placed in a mould and poured with polyamide plastic material (capron) after which it is machined in a lathe for imparting the required shape and dimensions to the part. In this way, the longevity of the part and the periodicity of unit lubrication are almost doubled.

The most frequently encountered disarrangement in the operation of the vertical shaft resting on a thrust bearing and a radial bearing is caused by the wear of the vertical shaft heel and thrust bearing. The worn-out thrust bearing is replaced by a new one and the vertical shaft heel is restored by metal coating or building-up. To ensure better reliability in the sliding thrust bearing operation it is replaced by an antifriction bearing. At repairs, a seat is made for the antifriction bearing in the body of the worn-out thrust bearing, and the vertical shaft heel is turned to suit the bearing ring. From the top the bearing is provided with a cover having a lubrication hole and the cover is placed on the vertical shaft. When the card coiler stands have a worn-out keyway at the point of its engagement with a gear they are repaired by planing the keyway or the whole length of the hub to ensure a more rigid connection of the vertical shaft with the gear.

Assembly and adjustment of cards. At the time of assembly of cards the top surfaces of the frames must be disposed strictly horizontally. The side plates of the main cylinder and doffers must be installed at an equal distance from their butt faces. The surface of the parts coming in contact with processed fibre is cleaned with an abrasive cloth, polished with chalk and wiped with graphite. It is necessary to ensure the mutual mobility of the flats in the set.

The set of flats must be assembled and mounted so that its motion is effected by easy turning with hand the socket wrench fitted on the worm shaft of the flat drive.

When adjusting the friction clutch it is necessary to find a position in which the pressure disk may easily be displaced by the action of the levers. The coiler mechanism must easily be turned by hand. On disengagement of different drives there should be no jamming in the connections. The grid bars under the taker-in and the mote knives must be set with minimum clearances. It is recommended to adjust the following reaches between the working organs of the cards, mm:

	Medium and fine stapled cotton	Staple fibre
Feeding table—licker-in	0.25	0.25-0.5
Feeding table—knife—grid bars	30-33	—
Licker-in—knife—grid bars	0.5-1.5	—
Licker-in—stripper roller	0.18	—
Stripper roller—working roller	0.18	—
Licker-in—main cylinder	0.18	0.17
Back knife—main cylinder:		
bottom edge—main cylinder	0.45	0.45
top edge—main cylinder	0.5	0.5
Flats—main cylinder		
in the case of a main cylinder with a whole metal saw-toothed fillet	0.2-0.25	0.25-0.3
in the case of a main cylinder with a needle fillet	0.22-0.25	0.25-0.3
Grid bars under the main cylinder		
from the side of the licker-in	0.75	0.75
middle	0.75	0.75
from the side of the doffer	1	1
Front knife—main cylinder		
to the main cylinder	0.45	0.5
to the flats	0.56	0.6
Mote knife—main cylinder and doffer	0.5	0.5
Flat roller or comb—flats	0.5	0.5
Main cylinder—doffer		
in the case of a main cylinder with a whole-metal saw-toothed fillet	0.125	0.15
in the case of a main cylinder with needle fillet	0.15	0.15
Doffer comb—doffer	0.25-0.3	0.25-0.3

At present methods have been worked out for the general adjustment of cards comprising the following operations:

antivibration packings are inserted, if necessary, under the frames of the cards taking into account the vibration resistance of the floors;

the ball bearings of main cylinders and licker-ins are replaced by new high precision bearings;

the main cylinders are dynamically balanced in their own bearings of the cards, for which special rings are placed at the ends of the shells on the cross-piece cover for attaching the balancing loads;

the licker-ins are statically balanced on special knife edges, and the doffers—directly on the card in their own bearings;

the main cylinders are ground in grinders of high precision in which the run-out of the grinding wheels does not exceed 0.02 mm;

covering of cylinders with a whole-metal saw-toothed fillet is made with an allowance not over ± 0.03 mm, and covering of the main cylinders and doffers is effected with a differentiated tension on the roller covering unit. Covering of the doffers with a whole-metal saw-toothed fillet must be carried out with variable tension

(at a distance of 200 mm from the edge the tension should be 50-60 N and 25-35 N in the middle part of the doffer). The main cylinders are covered with whole-metal saw-toothed fillet taking into account the working speed (so for instance, when the main cylinder diameter is 672 mm and its rotational speed is 800 min^{-1}, the fillet tension should be 67 N). The licker-ins are covered with saw-toothed fillet, and the carding rollers with whole-metal saw-toothed fillet;

levelling of the flat grid bars is made by means of a polymer coating with subsequent covering with an elastic and semirigid fillet.

The general adjustment of cards is most efficiently done at middle and capital repairs.

3. Drawing Frames and Sliver-Lap Machines

To prepare the drawing frames and sliver-lap machines for repairs, the half-ready goods are removed and the machines are dusted and cleaned.

The medium repair of sliver-lap machines comes to the following. The machine is put in idle running and the feeding rollers, the calender roll and disks are checked for run-out. Further, the machine is de-energized, the condition of the chain drive is examined and disarrangements are corrected (chain slackening, sprocket fitting), the condition of all surfaces coming in contact with the fibre is checked (indentations and burrs are smoothened), the braking arrangement is disassembled, checked and repaired, the antifriction bearings are opened, cleaned, washed and greased, other units and mechanisms are examined for ascertaining their proper condition and the worn out parts are replaced or repaired.

At the capital repairs of sliver-lap machines, they are completely disassembled and all worn-out parts and units are replaced. Next, the machine is assembled and adjusted. When proceeding to the adjustment, care should be taken that the pressure rollers on the feeding table turn easily, the top calender roll runs idle without jerks, the machine treadle with a tensioned belt brake lowers down 60 mm, the counterweight brings down the bobbins on the lapping rollers without impacts, the movable parts in the guides are easily displaced without jamming, the disks are properly mounted on the shafts, the surface of the braking disk is smooth and the belt uniformly adheres to it.

At the medium re pairs of drawing frames the following kinds of work are carried out:

the feeding mechanism—the guide is checked for easy running (if necessary adjusted) and the burrs on the feeding table and feeding roller are dressed;

the drawing mechanism—the line of rollers, pressure rollers and weighting hooks as well as roller stands, inserts and the drive to

the drawing mechanism are examined, and if necessary, the burrs are eliminated, faulty parts, coatings and combs are replaced and the reaches are adjusted to a template;

the mechanism for unloading the pressure rollers—the mechanism is checked and adjusted, the lines of weight suspension are levelled and the spring load is checked according to a control weight;

coiler and calender rolls—the shafts and drive to the coiler wheels are disassembled, the shafts are cleaned, all faulty parts are replaced, the main shaft and bearings are examined, the self-stop mechanism is dismantled, checked and adjusted, as well as the manual machine stop; all the machine parts are lubricated and the machine is adjusted.

At the capital repairs of drawing frames the guide mechanism is additionally dismantled, the drawing mechanism is completely disassembled, the rollers are mounted using the ruler, the framework is checked with a level, the can rotating tables are mounted with a plumb bob taking care of the excentricity; the main shaft is disassembled, the bearings are washed, the cleaning felts are replaced and all the parts which by their state and service term do not satisfy the conditions established for capital repairs are completely replaced.

At the adjustment of drawing frames care should be taken that the drawing frame moves smoothly (without jerks); that the load on the rollers is regular and equal, that no stoppage of cans occurs at the moment of reversing motion change-over that the self-stoppage mechanism ensures drawing frame stoppage in the course of two seconds in the event of sliver breakage, and that a strip of paper may be drawn between the calender rolls with application of a light effort.

Disks of the sliver-lap machine. At the time of web doffing (when th (disks are set apart) and its threading (bobbin clamping), the spindles carrying the disk are displaced. On machine starting, after web threading the bobbin turns between the disks which causes the wear of journals and metal sockets. Worn-out parts are replaced by new ones.

If the disks are broken at the place of fixing, then in repairing the central part of the disk should be bored, threaded and a steel ring is screwed on. Figure 67 illustrates the method of connecting the spindle *1* and pin *2* with the disk *3* ensuring a reliable operation of the lap rolling mechanism. The spindle is made with an elongated threaded tail. It is screwed into the disk, and the bobbin pin is screwed onto the protruding part of the threaded tail. The disk is made with right-hand and left-hand thread and is mounted so as to ensure its self-tightening during operation.

The calender roll of the drawing frame. In the course of operation the shaft journals are worn out, the fastening of the hollow cylinders is impaired and there is a run-out of the shaft and cylinders.

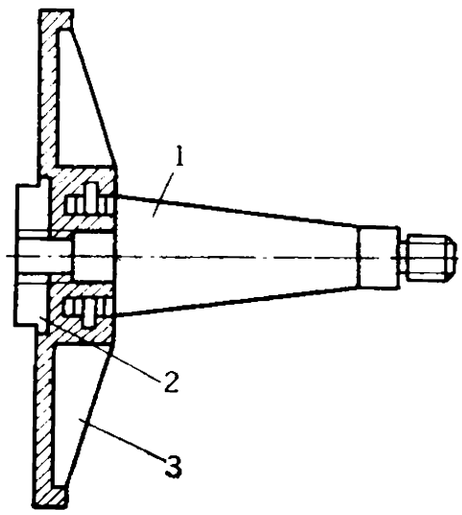


Fig. 67. Disks of bobbin clamping mechanisms in sliver lap machines

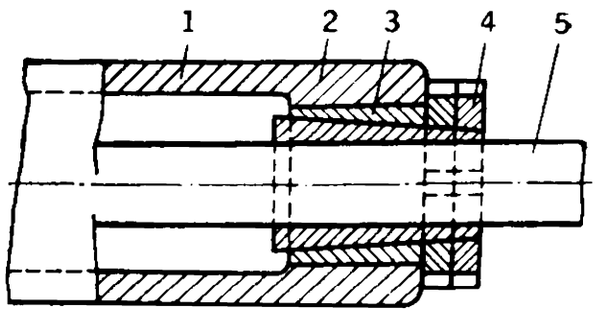


Fig. 68. Fixing cylinder on calender roll by means of tapered bushing

To eliminate this defect, the hollow cylinders are attached onto the shaft by aid of cone and bushing (Fig. 68) instead of key joints. A conical hole is bored in the hollow cylinder *1* and a bevel bush *2* is mounted on the shaft *5*. The nut *3* is screwed onto the threaded tail, the bush *2* is tightened, and the nut *4* is used as a counternut for final tightening. This kind of repairs ensures the alignment of the shaft and cylinder and allows the easy removal and mounting of cylinders.

Drawing frame combs. In wool and flax spinning mills drawing frames are provided with combs consisting of a plate with pressure fitted round needles. At the ends of the comb plate there are provided chamfers by means of which the combs penetrate between the worm coils.

In the course of operation, the comb chamfers are worn-out, the needles are broken, fall out of the plate which also comes out of order. The combs with worn-out chamfers are restored by gas or electric-arc welding, and in the event of small wear by the electric spark method. The metal overlay is ground. The deteriorated needles are eliminated and new ones are pressure fitted in their place.

In addition to combs with round needles there are also combs with flat needles. Such needles are attached in the comb plate with polymer material and owing to its elasticity they acquire flexibility which is necessary when operating with products passing at a great speed. The method of fixing flat needles in the comb plate by means of polymer materials is shown in Figure 69. The needles *1* are placed in the elastic polymer holders *2*, which are introduced in the longitudinal slot *3* of the steel comb *4* and attached by the clamp *5*. If one or several needles get out of order all the package is eliminated by using a special device and replaced with a new one.

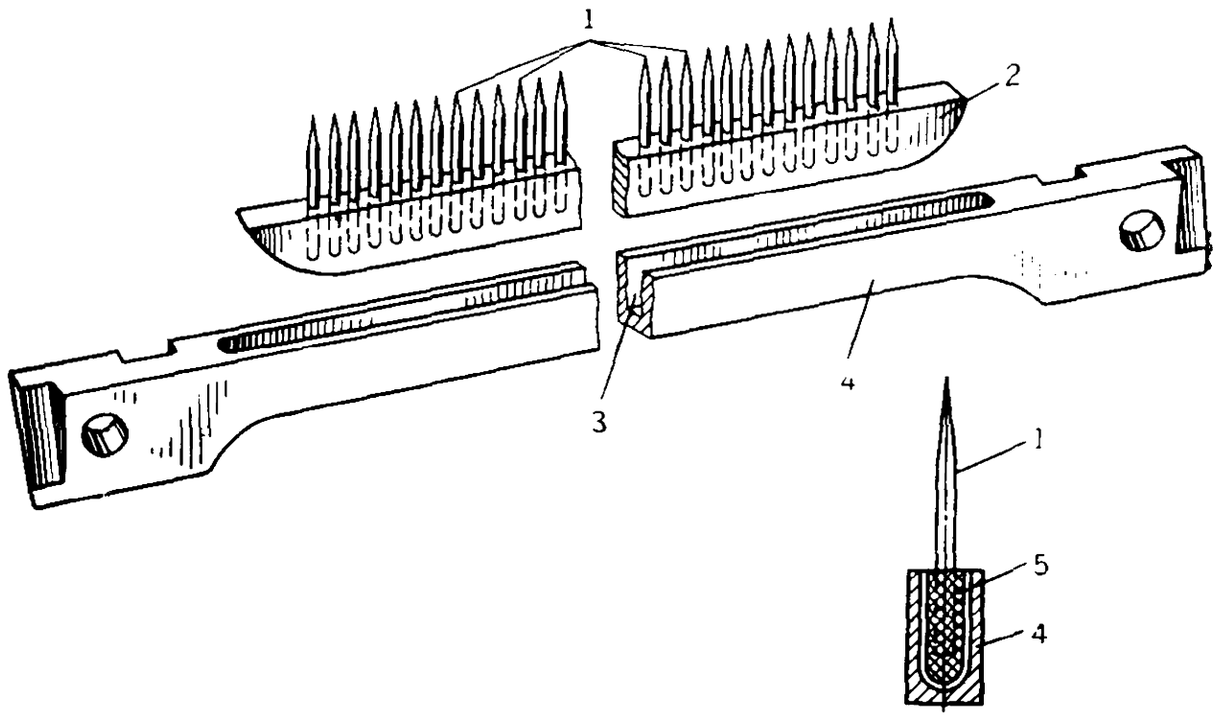


Fig. 69. Fastening flat needles in comb plate by polymer materials

The defectuous combs are removed from the drawing frame to be checked: the needle plates are checked for rectilinearity in longitudinal and crosswise directions and their heads for twist. The comb resting with its ends on bearers should have no oscillating motion. If necessary it is straightened in a special device. All the needles must be disposed on the same level, aligned along the axis, and should be vertical and oriented in the direction of fibre drawing. Even one curved needle can bring the entire fillet out of order. If necessary bent needles are straightened by a tubular tool.

Assembly and adjustment of sliver-lap machine and drawing frames. At the assembly of sliver-lap machines the guiding spikes on the feeding table are set so that the slivers before the calender rollers form a regular web. The rest of the bottom cleaner weight is set so that the weighting lever does not reach the shaft when the cleaner is removed. The pedal of the machine with a belt brake must have the possibility of lowering by 60 mm when the brake is tensioned. The pressure rollers must freely rotate and in the absence of sliver there should be no clearance between the pressure and feeding rollers. The bobbins must come to rest on the lapping rollers without impacts. The top calender roll must freely rotate (without jerks) at idle running. The movable parts should not be clamped in the guides. When adjusting the brake care should be taken that the braking band uniformly contacts the braking pulley; the surface of the braking disk must be smooth and the disks should not be slack on the shaft. Self-stops should come in action so as to ensure that in case

of breakage, the sliver end passes not more than over a distance of 200 mm.

At the assembly of drawing frames the framework position should be checked in horizontal and vertical planes. The fluted roller, top rollers of the feeding couples as well as the smooth roller should be free of burrs. The rollers must easily rotate and the run-out should not exceed 0.25 mm. The needle bearings must be in good order and packed with grease. The pneumatic system for fluff elimination must be hermetically sealed and reliably fixed. The feeding trough a and the working surface of the condensing funnel must be smooth and well-polished. The calender rolls are set to allow a strip of thin paper to be drawn between them by applying a small effort.

At the adjustment of sliver-lap machine and drawing frames it is necessary to observe the admissible allowances in deviations for the wear of working organs which were established at the repairs and to maintain the allowable reaches according to adopted technological conditions.

4. Roving Frames

For preparing the frames to be repaired, the roving and half-ready goods are eliminated from the frames and they are dusted.

At medium repairs the following work is to be done:

the roving creels—these are checked to the pin, the faulty thrust bearings are replaced, the rods, flanges and the feeding roller are checked for rectilinearity, the fastenings are examined if necessary tightened;

drawing system—the following parts are disassembled, checked and adjusted: gearings, spindles, fluted rollers, stands, bushes, cap bars, guide nebs; the rollers and eyelets are cleaned; the springs, cleaners, covers, deteriorated gears and spindles are replaced; faulty cradles, forks and belts are examined and replaced; the drawing system is assembled and the reach between cylinders is adjusted according to a template;

the bobbin rail—the flyers are checked and removed, the jack shafts, jack and bobbin gears are checked and straightened, the faulty spindle bushes, the jack couplings and bearings are replaced and cleaned, the jack shafts are set according to a template, the drive is checked, the faulty gears and spindles are replaced and the leaf chain is washed;

spindle rail—the spindles, jack shafts, jack and spindle gears, thrust bearings and jack bearings are checked, replaced or repaired;

lifting mechanism—the shaft, couplings, bearings and racks are replaced or faulty parts are repaired;

reversing motion—the plates, balance, spindles and springs are checked and cleaned, and faulty parts are replaced or repaired;

bevel drums—checking for run-out and easy rotation; the bearings, gear drive, lock and lifting mechanism of the bottom drum are examined and faulty parts are replaced or repaired;

head drive—the main shaft, differential gear, gear bearings and spindle drive are checked and faulty parts are replaced or repaired;

hoods and guards—are checked and if necessary repaired.

Finally the roving frame is lubricated and put in idle running.

Capital repairs (overhauls) of roving frames comprise the following operations: full disassembly of the frames; cleaning and washing of parts; checking the beams, stands and rails; repair of all rollers and checking of each joint; repair of all roller stands, replacement of jack shafts and worn-out jack gears; full replacement of all spindle bushes, thrust bearings and spindles; examination and restoration of the slots for the rail in the stands; checking and repair of all kinds of transmissions (gearing, chain and belt transmissions and also of the reversing motion).

For the **adjustment** of the roving frame after the assembly it must be set in idle running. During idle running it is essential to check the smooth operation of the roving frame, the heating-up of separate parts and units and to ascertain that there are no foreign noises during the running. Further, the spindle and bobbin rails are checked for horizontality. The stroke of the traverse should be equal to 75% of the working length of the shafts in the back line, and the distance between the extreme positions of the roving to the shaft ends should be equal. The centre lines of the bevel drums should be strictly parallel and in the same plane.

FLUTED ROLLERS. In the course of roving frame operation the fluted rollers are bent, their journals are worn-out, the flutes become damaged and breakages occur at the places of threaded joints.

At machine repair, the rollers are removed from their bearings and placed on supports arranged along the machine. The line of rollers consists of staffs connected by threads. Several jacks are used simultaneously for removing the rollers. The rollers taken off from the roving frames are separated in staffs and each staff is checked with an indicator for determining which of them is bent and needs dressing. The roller staffs are dressed by means of a cramp on a lathe, a press or in a special machine. After dressing the roller run-out at the exterior surface of the fluted sections should not exceed 0.1-0.12 mm.

If the supporting journals of the fluted roller are worn-out, they are restored by chromium plating, metal coating or building-up.

Rollers with a deteriorated fluted surface are repaired as follows. Different shallow scratches, indentations and burrs are eliminated with a needle file or trihedral scraper and then the rollers are polished with a paste of thin abrasive powder mixed with pure mineral oil.

Worn-out flutes of unhardened rollers are restored by plastic deformation, by rolling over the cavities with a steel hardened roller

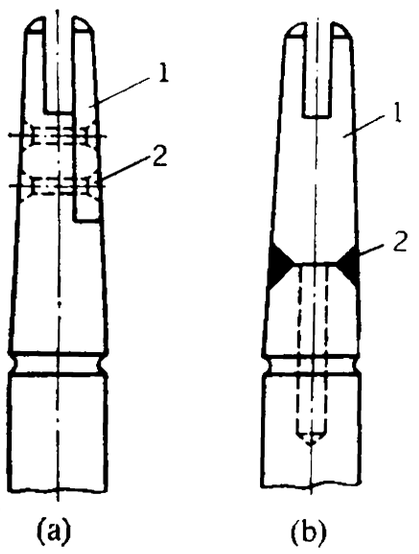


Fig. 70. Device for repairing roving frame spindles

under a high pressure. Worn-out flutes of hardened rollers are deepened by a thin abrasive wheel or a shaped tool of hard alloys in a slitter using a grinding head instead of the top carriage. To restore the service ability of the fluted roller it is sufficient to remove from the cavity a layer of 0.08-0.1 mm.

SPINDLES. In the course of operation spindles may be bent, heels, necks and seating cones of the flyers may become worn out, the slots for the flyer and eyelets may break. The bent spindle is straightened under press on a straightener or by means of different devices.

The deteriorated spindle heel may be repaired by different methods. The spindle end is annealed and dressed on a lathe to obtain the required cone after which the spindle is hardened again and machined. Another more efficacious method consists in grinding without preliminary annealing and with subsequent hardening, but this method requires the use of a special device. When repairing spindles with worn-out heels, care should be taken that the height of spindles in one set used in a roving frame does not differ more than by 1.5 mm.

The worn-out neck and seating cone for the flyer are chrome plated. The worn-out slot is repaired by soldering a layer of brass or by electrolytic steel plating.

The spindles with broken eyelets are repaired as follows: if one eyelet is broken off (Fig. 70*a*), then an insert *1* is attached with two rivets *2* to its place. The points of joining should be soldered with brass or copper. If both eyelets are broken (Fig. 70*b*), the spindle head is cut-off and a new head *1* is threaded to its place and the butt faces *2* are soldered with brass or copper. After soldering the head is carefully finished.

The shift of the slot centre line in respect to the spindle centre line should not exceed 0.15 mm. The run-out in diameter of the fitting cone is 0.15 mm and the run-out in diameter of the fitting cone for the flyer, heel and cylindrical part should not exceed 0.07 mm.

FLYERS. In the course of operation the following disarrangements of flyers may occur: wearing out of the fitting cone and pin, the flyer seat, and the bottom part of the flyer hollow leg; change in dimensions and deterioration of the shape of the hollow leg slot; strong disbalance, wear and breakage of feet; disbalance of the flyer balancing branches; burrs, indentations, scratches, and other exterior defects.

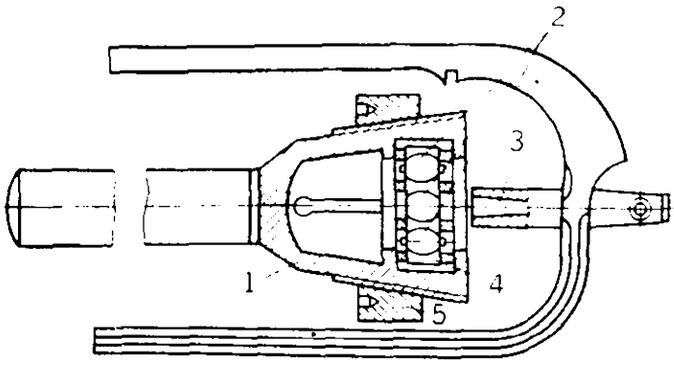


Fig. 71. Device for reducing bush of roving flyer

Flyers are repaired in a shop where they are sent to after removal from the spindles. Prior to the repairs the flyers are cleaned from dirt and fluff manually and in special devices. After cleaning, the flyers are washed in a bath with a soda solution. Lately for cleaning flyers ultrasonic units have found application. Reburring of flyers is effected by means of a needle file or emery cloth. A special milling cutter with small teeth disposed on the interior cone is used for eliminating burrs from the flyer head. The milling cutter is fixed in the spindle of a drilling machine, and the flyer—in a special device on the table so that the flyer head is disposed opposite the milling cutter. On the displacement of the rotating milling cutter along the head of the flyer, the teeth remove a very thin layer as if scraping the head.

For repairing a flyer with a worn-out fitting cone, the bushing is reduced. The worn-out flyer bushing is drawn under press through a calibrated hole of a steel hardened mould. Considering the fact that the bushing may be worn-out differently, the press has a set of moulds with holes of different diameters.

Figure 71 shows the device for reducing the bush on a lathe. Barrel-shaped steel rollers *2* are arranged in special shells *4* in the collet chuck *1*. By rotating the nut *5* the rollers may be approached to the centre or retreated from it. The collet chuck is attached by its tail in a three-jaw chuck screwed on the spindle of the lathe headstock. The flyer *3* is attached in a chuck on the tailstock sleeve. The collet chuck device is rotated and the flyer bush is mounted between the rollers and reduced. If necessary after each passage the rollers are tightened with a nut. Sometimes the bushing is reduced manually (by knocking with a hammer), but the quality of machining in this case is very low. After the bush cone has been reduced it is calibrated by a conical reamer. The reamed conical hole is checked by a bevel gauge (plug) and spindle. The worn-out pin is replaced by a new one. The flyer head eyelets are ground using a thin emery cloth with chalk and oil and next polished with a paste or fine emery mixed with oil by means of a wooden lap attached in the drilling machine.

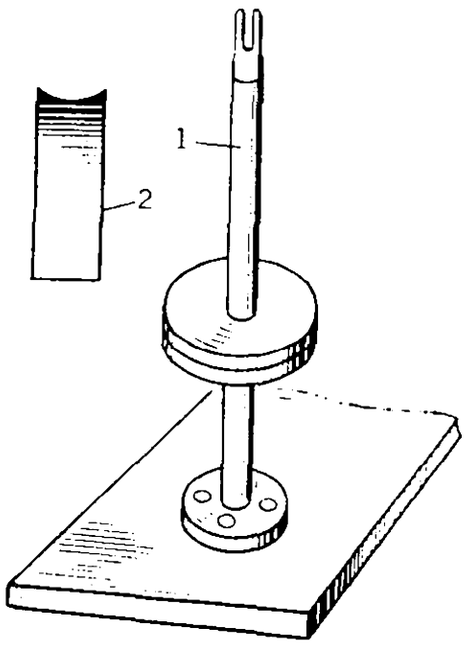


Fig. 72. Instrument for controlling roving flyers

Worn-out seats and locks of the flyers are repaired by building-up (soldering) with brass and are sawn to a template. The vertical displacement of the foot on the seat should not exceed 0.6-0.8 mm. The bottom worn-out part of the flyer hollow leg is sawn off and a tubular insert is butt-welded after which it is carefully dressed and polished. The slot in the flyer hollow leg with modified initial shape and dimensions is bent in by means of a special plate and copper hammer, or spread using a special mandrel. The slot profile at dressing is checked with a gauge. The distorted flyer legs are straightened as usual or in a straightening die under press.

In dressing the rectilinearity and parallelism of the flyer legs are checked by means of the instruments shown in Fig. 72. The flyer and template *2* are fitted on the instrument spindle *1* and the template recess is applied to the spindle.

The radius of the flyer leg bend is measured by a gauge. After the flyer legs have been repaired and straightened, the flyers are polished and the finish of their surfaces should be rather high not under the 9-th class of finish. The flyer foot has two legs: the horizontal one for guiding the roving to the bobbin and the vertical one for pressing the foot to the bobbin (by centrifugal force) so as to ensure the required density of yarn winding on the bobbin. The following conditions are essential for the normal operation of the flyer foot: unchanged mass and proper disbalance of the foot, as well as its clean surface.

In the course of operation feets change their shapes and may become sometimes broken. The deformed feet are restored by straightening with a copper or lead hammer using special techniques (Fig. 73*a-e*) and a device with a set of plates (Fig. 73*f*) suiting the dimensions of the flyers. For straightening and bending new and restored feed different kinds of dies are used. The yarn guide eyelets are polished first with fine emery cloth using chalk and oil and then with wooden laps using fine emery and oil. At present, use is made of electropolishing and ultrasonic processing. The broken feet grippers are made anew and then welded or soldered to the rod, taking care that the supporting edges of the gripper are fitted to the flyer seat so that the foot is 1 mm away from the instrument disk and comes in contact

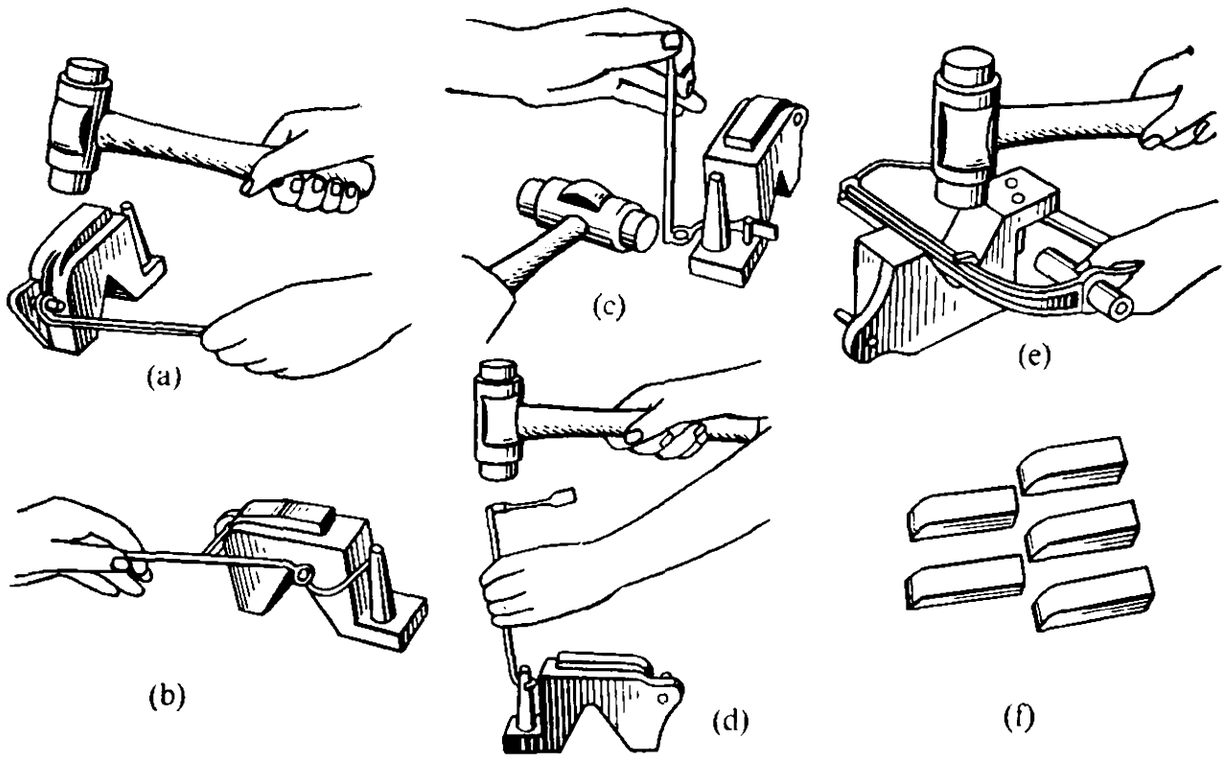


Fig. 73. Procedures for straightening roving flyers

with the spindle at rotation. The deviation of the foot on the seat in vertical direction should not exceed 0.8 mm. The eyelets of repaired feet in fitting onto the flyer must coincide with the matchmark on the disk of the control spindle. The method of fixing the foot on the flyer is shown in Figure 73*e*. The foot clearance should not exceed 0.8 mm.

Roving flyers are subjected to static and dynamic balancing. Figure 74 illustrates the diagram of an instrument for the static balancing of roving flyers. The flyer *1* with the foot *2* is fitted on the spindle *3* attached in the bushing that freely rests on the bearings *4* in prisms *9* mounted on the stand *8*. The stand is placed in a strictly horizontal position according to a level by means of adjusting screws *7*. The pointer *6* connected with the bush slides on the circular scale *5* graduated for reading the disbalance. If the flyer is not properly balanced the pointer deviates.

When checking the flyer for dynamic balance it is fitted on a spindle of a special instrument and put in rotation at the working speed. When the flyer is properly

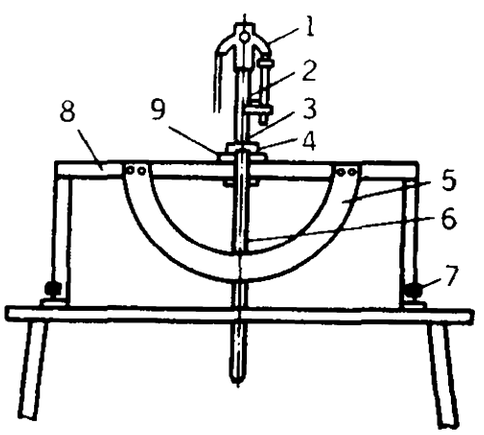


Fig. 74. Device for static balancing of roving flyers

dynamically balanced, the system will be in equilibrium. When the flyer is out of balance the disk of the instrument will deflect. On the disk there are two marks indicating the amount of admissible disbalance for each type of roving frames.

Table 2 shows the spindle rotational speed at which the flyers are tested and the allowable values of disbalance.

Table 2. Disbalance of Roving Flyers

Roving frame model	Spindle rotational speed, min^{-1}	Allowable disbalance in reference planes, g cm	
		I-I	*II-II*
P-160*	700	5	75
P-145	750	5	55
P-130-1, P-130-2	1000	5	45
P-115	1200	5	45
P-105, P-95, P-85, P-75	1400	5	40

* P-160 is a roving frame having a spindle spacing of 160 mm.

The deformation of the flyer legs is checked on a special instrument for determining whether the flyer leg deformation at the working rotational speed corresponds to the allowable values given in Table 3. The strength of flyers is determined in the same way. At working rotational speeds no residual deformations or cracks should appear and the welded joints should not be deteriorated.

Table 3. Elastic Deformation of Flyer Legs

Roving frame model	Flyer rotational speed, min^{-1}, at testing		Allowable elastic deformation at the end of the leg, mm	
	for elasticity	for resistance	working	balanced
P-160	700	950	2.5	4.0
P-145	750	950	2.5	4.0
P-130-1, P-130-2	1000	1200	2.5	4.0
P-115	1200	1450	2.5	4.0
P-105, P-95, P-85, P-75	1400	1700	2.5	4.0

DIFFERENTIAL MOTION. The main function of the roving frame differential motion is the addition of component speeds, i.e. of the constant speed of the main shaft and the variable speed of bevel drums as well as the transmission of the speed to bobbins. The differential motion consists of main members (central gears and carrier) and satellites—gears with shafts moving in space.

In the course of the differential motion operation the following disarrangements may be observed: cracks and crushing of holes in the body and cover, wear of gear shafts, teeth and other rubbing surfaces of gears, wearing of bushes.

In case of small cracks in the body and cover of the differential, the crack is opened and soldered with brass by means of a gas flame. Crushed seating holes are restored by a hole trueing multiflute drill and a repair bushing manufactured of antifriction cast iron to suit the new size of the hole.

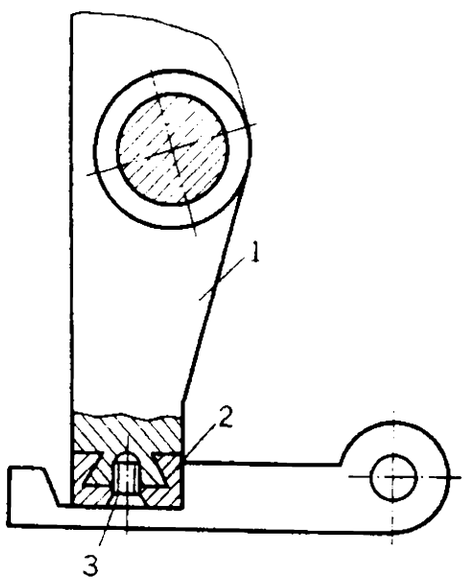


Fig. 75. Method of attaching blocks in reversing motion of roving frame

The gears with a shank and the gear shafts are carburized, hardened and ground to the seventh class of finish. Sometimes grinding and chromium plating are used. When repairing gears with a spindle (due to the wear of the spindle) the deteriorated spindle is cut off, the gear is drilled, reamed and a thread is cut. Next, a new spindle with thread is manufactured, both parts are connected by threading and pinned. When the toothing of internal gears is worn out they are repaired by built-up with further machining on a gear shaper. If such machines are not available, machining is carried out on a planer with special devices.

In the recent time when repairing the roving frame, the differential gears are mounted on antifriction bearings which considerably improves the reliability of the differentials and reduces parts consumption.

REVERSING MOTION. This is an intricate mechanism controlling the process of roving winding on the bobbins. In the course of operation the fastenings of the swinging rocker sliding blocks become slack and the following parts are subject to wear: spindles, rollers, rockers, swinging levers, toothed racks, gears, pawls, etc.

The worn pawls are replaced by new ones or repaired by building-up. The slack fixture of the rocker blocks is tightened and the worn blocks are replaced by new ones. In order to ensure a more reliable fixing of the blocks *2* (Fig. 75) they are dovetailed on the swinging lever *1* and tightened with screws *3*. As the reversing motion is assembled, the pawls and rockers are mutually adjusted so that each pawl contacts the rocker with its full working surface. In locked position the clearance between the pawl and the rocker should not exceed 0.2-0.25 mm; at change-over one of the pawls must perfectly be en-

gaged, while the other must simultaneously be disengaged, and vice versa. It is convenient to carry out the repairs and adjustment of the reversing motion on a special stand in a workshop.

ASSEMBLY AND ADJUSTMENT OF ROVING FRAMES. As the roving frames are assembled and adjusted the roller beam should be strictly in horizontal plane. The allowable deviations in cross and longitudinal directions should not exceed 0.1 mm per running metre of the beam. The drawing system should operate smoothly and without jerks. The feeding roll must be smooth and free of indentations and burrs. The slider of the roller stand must be easily displaced with an allowable clearance not in excess of 0.3 mm.

The flyers are washed, examined, balanced and carefully ground.

The bobbin rail is checked for horizontality with a plumb bob and the spindle rail with a template. The rail lift is checked according to the bobbin working height. The bobbin rail must move smoothly. The shafts of the bottom and top conical drums must be strictly parallel and in one plane. The drums should be easily rotated by hand.

The reversing motion comb is set horizontally with the foot in middle position on the bobbin and the reducer shafts parallel to the beam of the spindle rail; the run-out of the reducer should not exceed 0.15 mm and of the licker-in 0.3 mm.

The reversing motion screw is set vertically. When the gear is removed, the reversing motion screw must easily rotate in bearings. The longitudinal slot of the stop is set parallel to the reversing motion screw so that the protrusions of the shells fitted on nuts would penetrate in the longitudinal slot.

At any position of the bobbin rail the preliminarily fixed shell stops must not be clamped. The stop is set in height so that when adjusting the rail for the preset height of nut lift, it is disposed symmetrically to the screw cut-out. The bracket of the roller with a flywheel for manual cranking of the reversing motion should be set so that when the roller is completely pushed inside, its key is opposite the bushing of only one gear.

The mechanism of the shifter must operate smoothly without jamming and the shifter must move over the full length of the conical drums. When the shifter is in the position corresponding to the beginning of winding, the weight on the reversing motion block must be in upper position. When the shifter is in opposite position, the weight must not touch the floor. It is necessary to check the reversing motion for easy running. All the spindle heads must be disposed on one horizontal line. The rollers must rotate easily, their surfaces must be properly ground and the loads on the rollers must be maintained strictly the same along the lines. Deviations in the reach of the nebs should not exceed 0.2 mm; the carrier eyelets must not let the web approach closer than at a distance of 3-4 mm to the ends of the

top roller elastic part. Allowable deviations in rectilinearity of the drafting field, i.e. of the tangent in respect to the roller working surface should not exceed 0.25 mm; the web condensers should be free from indentations and burrs.

5. Combers

When preparing the combers for repair, the lap is knocked off, the half-ready products are eliminated, the wastes are removed and the combers are cleaned and dusted.

In **medium repairs** of combers the following jobs are done on the following units:

feeding arrangements—examining and tightening the unwinding rollers, deburring the feeding rollers;

nippers, detaching rollers, needle segments and combs—checking the detaching rollers, segment drums and combs, nippers, ratchets, leverage systems, fingers, bearings and bushes; replacing worn parts; straightening bent needles on drums and combs, and rubbing separate rollers with chalk;

head gearings—examining the transmissions, replacing faulty parts, and the adjustment of meshing;

draw box—disassembling and checking the top and bottom rollers and bearings, cleaning with chalk and deburring the rollers, replacing worn coatings, inspecting the draw box drive and replacing faulty gears and spindles;

coiler—checking the drive, replacing worn parts (gears, spindles and others), cleaning the cover in the trumpet with chalk;

cleaning brushes, doffers and combs—the examination of brush and doffer bearings, fixing the brushes and combs;

self-stop motion—checking and disassembling the motion, replacing worn parts and their adjustment.

At the **time of adjusting** the comber after the repairs, the reaches are checked with gauges. Using an indicator and gauges adjustment is made of the nippers, detaching rollers, top combs and feeding rollers. The proper interaction of working organs is determined by the cycle diagram and cycles dial. The following requirements should be met: the half laps must be attached on the shaft in strictly fixed position so as to obtain a clearance of not over 2 mm between the comb segments.

NIPPERS. Each comber delivery is provided with nippers. The lap is clamped between the lower and bottom nippers (called a cushion plate and a nipper knife correspondingly). In the course of operation the nipper edges or lips become worn. The clamping part *1* (Fig. 76) of the upper nippers *I* comes out of order, while in the lower nipper *II*—the clamping lug *2* is worn. This impairs the combing quality and causing an irregularity of the combed sliver.

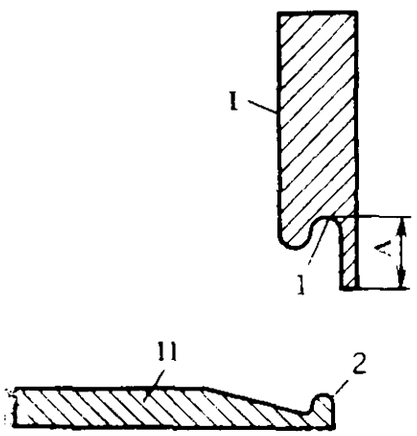


Fig. 76. Nippers

If the wear is inconsiderable the surface of the nippers is smoothened with a file or emery paper. In case of bad wear, the worn parts of the upper nippers are planed with a shaped cutter or milled with a shaped milling cutter, taking care to strictly maintain the dimension *A*.

After planing or milling, the nipper surfaces are rubbed with cast iron or wooden laps and paste (abrasive and oil). The uneven surface of lower nippers is scraped and lapped with paste. Next, the nippers are put in pairs (the upper and lower nippers) and are lapped. The accuracy of fitting is determined by inserting a strip of cigarette paper which must be properly clamped at any point of the nipper surface.

SLOTTED CAM. This cam serves to impart motion to the back detaching rollers moving on the detaching cylinder. In the course of operation the cam slot becomes worn. In case of local wear, in repair the deteriorated part of the slot wall is cut-out and in its place (using a gauge and roller) an insert is welded and the slot is carefully filed. If the slot is worn-out throughout the full perimeter, the slot is straightened, widened by milling and the roller is replaced by a thicker one.

The worn-out cam slot is milled in a vertical milling machine equipped with a special device.

CIRCULAR BRUSHES. Cleaning of half laps is effected by brushes consisting of two half-cylinders with holes for attaching tufts of rigid Mexican grass or bristles. In the course of time the grass or bristles fall out and lose flexibility which results in poor cleaning of the half lap. For levelling the brushes in circumference, they are sheared by a special device mounted on a circular grinding machine.

For increasing the strength of circular brushes it is recommended to fasten the bristles *1* (Fig. 77*a*) on a cylindrical solid block by means of special pins *2*. In some cases, the circular brush made of bristles or grass pile is replaced by a circular brush with straight needles of steel or brass wire *1* (Fig. 77*b*) attached in an elastic rubberized foundation *2*, having its ends without needles nailed to the face of the hollow half cylinder *3*.

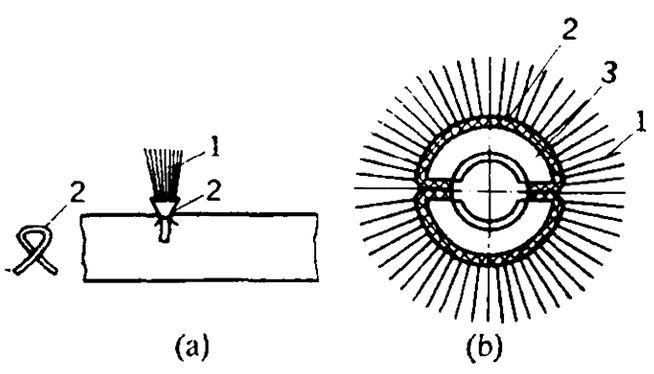


Fig. 77. Circular brush

Two such half cylinders are pressed together at the ends by shrink rings. Brushes of this design are reliable in operation and ensure a good cleaning of half laps.

HALF LAPS AND TOP COMB. In operation the needles of comb segments and comb strips are deteriorated or broken and the top combs are also broken.

Faulty comb segments and top combs are repaired in a specialized shop. The comb segments are disassembled, the faulty strips are unsoldered, checked and straightened, the needles are set, soldered to the strips, washed, dried and scraped, the segments are assembled, checked with a gauge, and ground. The strips removed from the segment are graded, faulty needles are unsoldered and eliminated; the strips are checked for rectilinearity and distorted strips are straightened (dressed) in a straightening die.

Setting of the needles is effected manually by means of a special device.

After setting, the needles are levelled in height by means of a hammer and a strip, fixing with screws the position of the latter. Next, the needles are soldered to the strip. The soldered combs are washed, dried, and scraped after which the assembly of half laps is started. At the assembly, the correct position of the strip is checked by passing a 1-mm thick lamellar gauge between the sharp ends of the needles and the setting strip. After the strips have been checked throughout all their length, they are definitely fixed in the segment slot. To accelerate the adjustment of strips, the assembled half lap is ground in a lathe using an eccentric mandrel (with central holes shifted by 1.8 mm). Owing to the center shift the required eccentricity in the position of needle points is obtained. After the assembly, the half lap is polished with circular brushes and oil. To avoid the corrosion of half laps and top combs, they are stored in special cabinets and powdered with chalk or talc. Prior to the installation on the machine the half laps and top combs are again polished on a special machine.

ASSEMBLY AND ADJUSTMENT OF COMBERS. At the assembly of combers the half laps are mounted so that the needle points of the first strips and comb segments are in the same plane with the front edge of the upper nipper (when the nippers are closed).

The distance between the upper and lower nipper edges should not exceed 1 mm; the working edges should be well scraped; the reliability of nipper clamping is checked by passing a strip of cigarette paper

The feed of separate portions of fibres must be within 20-35 mm. The top comb is mounted with a clearance of 1 mm in respect to the detaching roller which corresponds to the 62nd division of the cycles dial. In height, the top comb is placed in the position corresponding to the 38th division of the cycles dial. In this position the

distance between the top comb and the gauge placed on the generatrices of detaching rollers may be 1 to 3 mm.

The brushes should penetrate in the needled surfaces of the half laps not more than by 2 mm.

The feed of the web into the comber, the rotational speed of separate rollers and comb shaft are adjusted to suit the kind and linear density of processed fibres.

6. Spinning Frames

Ring Spinning Frames

The ring spinning frame consists of the following units and mechanisms: the creel for roving bobbins, the drawing unit, the headstock gearings, the builder motion, the ring plate and separators, spindle units, the lappets and yarn guides, tin drums, and tension rollers.

The spinning frame is prepared for repairs by breaking-off the roving, eliminating half-ready products from the frame, doffing the yarn and dusting the frame.

During **medium repairs** of ring spinning frames the following jobs are carried out on the following units:

creel for roving bobbins—the creel is checked according to the skewer, faulty cup-shaped porcelain footsteps are replaced, the creel is reinforced, the rods are examined and the boards are repaired;

drawing unit—overall inspection of the drawing unit; checking, replacing or repairing faulty gearings, rollers, roller stands, inserts, cap bars, cap bar nebs, forks, aprons, springs of clearers and traverse guides; adjusting the traverse guide and scraping the eyelets; removing indentations and burrs in the cylinders, and setting the reaches according to a template;

headstock gearings—disassembling, checking, repairing and replacing faulty gears, spindles and bearings; cleaning and repairing the oil line;

builder motion—disassembling, cleaning, examining, replacing and correcting the pokers, builder arms, chains, builder cams, tie rod bowls and rockers, including their lubrication;

ring rail and separators—checking the condition and fastenings of rings; replacing faulty rings; wiping the rings with chalk; checking the ring rail; installing clearers, and travellers, checking and fixing the separators in relating to spindles and ring rail, and replacing faulty separators;

spindle units—washing and inspecting the spindles; replacing worn-out bushings, bolster and spindle blades; and filling the oil in the spindle bolster;

lappets and yarn guides—inspecting and reinforcing the lappet beam; checking the condition and replacing worn out lappets and yarn guides; checking the yarn guides in relation to spindles; and dressing the eyelets;

tin drum and tension rollers—checking the drum for run-out, inspecting, repairing or replacing faulty tension rollers; and repacking the bearings with grease.

At **capital repairs** the machine frame is additionally checked using a cord, a ruler, a plumb bob, and a level; the drawing unit is completely disassembled as well as the machine drive, spindles, drum, tension rollers and yarn guides. All faulty parts are replaced or restored, the drum is balanced, the spindles and antifriction bearings are disassembled, washed and lubricated.

At **machine adjustment** a special attention is paid to the tension arrangement, and the drive of the drum and spindles. The quality of repairs is assessed by the quality of produced yarn, its proper winding of the tube and the breakage rate.

The roller beams and spindle rails are checked for horizontality in longitudinal and cross directions, the allowance for deviation being 0.15 mm per m of the stand length. The web should be kept at least 3 mm away from the edge of the roller working surface. When installing the broken-end collector, care should be taken that the clearance between the roller and the broken-end collector tube should not exceed 3 mm. The spindle setting is checked by a special template.

DRAWING UNITS. The main parts of drawing units are roller stands, fluted rollers and top rollers.

Roller stands. In the course of operation, the roller stands serving as a framework for the drawing units are mainly deteriorated in their seats. When repaired, the worn-out parts are usually built up with bronze brass or babbitt after which they are milled or bored and then filed to the preset dimension.

Installing new linings is the best way of repair. In this case the seat of the roller stand is shaped as necessary and a bushing of antifriction metal or plastic material is inserted under pressure. For example, in the drawing unit of the spinning frame П-83 (the ring spinning frame with a spindle spacing of 83 mm) the worn seat of a roller stand of 18 mm in diameter is bored to a diameter of 25 mm with an allowance for a shrink fit of a cast iron or plastic bushing. The bushing has an outside diameter of 24 mm, with a length corresponding to the thickness of the stand (38 mm) and a hole 18 A_3 shifted 3 mm from the center. The ready bushing is pressed into the bored hole in the stand, after which the remaining thin walls of the bushing are sawed and finished to suit the dimension of the roller neck. The bushing is fixed in place with a screw. The worn bushing may easily be replaced. Practice shows that the most reliable fastening is obtai-

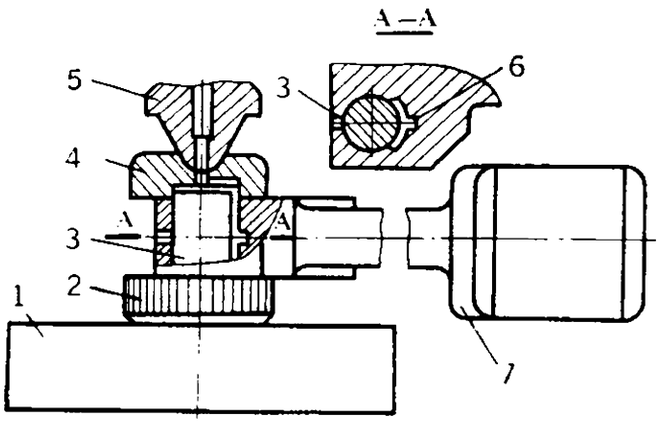


Fig. 78. Method of repairing bushing of roller stand in drawing unit BP-1M

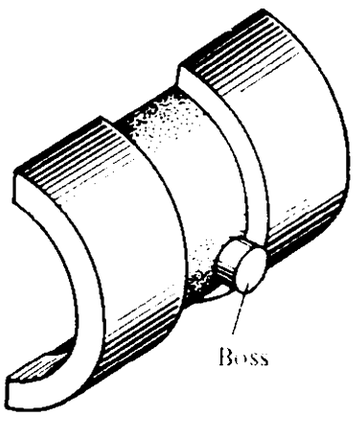


Fig. 79. Shape of bushing with lug

ned by using a bushing of fabric-based laminate in dovetail shape

Capron bushings have found application in many textile enterprises. When repairing apron draw boxes, a capron bushing is poured into the roller stand, as shown in Fig. 78. The roller stand *7* resting on the support *2* is placed on the table *1* of the casting press. The rod *3* with a nominal diameter corresponding to the diameter of the roller neck is inserted into the stand hole. The cover *4* with a central hole for pouring the capron is placed at the top. The mould is provided with canals and holes for air elimination (casting system). The casting press nozzle *5* is placed against the cover and melted capron is injected inside. The place of bushing casting has the shape of position *6*. After a certain time the mould is splitted, degated, and beads are eliminated.

For roller stands of drawing units in flax spinning frames, bronze bushings are used. The wear of these bushings results in non-coaxiality of their position as well as in excessive bending and run-out of weighted fluted rollers. In repair, it is essential to use plastic inserts (bushings) of antifriction material, which are ten times cheaper than bronze bushings. Moreover, as experience shows, it is efficient to use cylindrical bushings with a lug (Fig. 79) protecting the bushing from shifting. All the set of roller stands on the frame (irrespective of the design of the drawing unit and the type of spinning frames) must have bushings of the same size corresponding to the diameter of the fluted roller necks.

Fluted rollers. In combination with top rollers, the fluted rollers serve for the attenuation of sliver or roving. According to their position in the drawing unit, the roller staffs are subdivided into head, intermediate and off-end staffs, and correspondingly the rollers are provided with different flutes (trapezoidal, rhombic, etc.).

In the course of operation the journals, necks and fluted surfaces of the rollers are subjected to twisting, bending and rubbing, which can provoke the following disarrangements: residual bend, wear of

necks, crushing and breakage of tails and seats of the staffs and wear of fluted surfaces.

Residual bending is due to the overloading of the roller or to its improper assembly (when the line of rollers does not rest on all the bearings). The rollers are checked for run-out using a special indicator directly on the spinning frame. The necks are worn because of insufficient lubrication and low rigidity of the roller line. The tails are broken due to the lack of proper threading in the staff seats. The fluted surfaces of the rollers are worn down by rubbing with the top rollers, when the web is cut with a knife or hook and also when the flutes are impaired by the yarn due to the insufficient displacement of the yarn guiding rule.

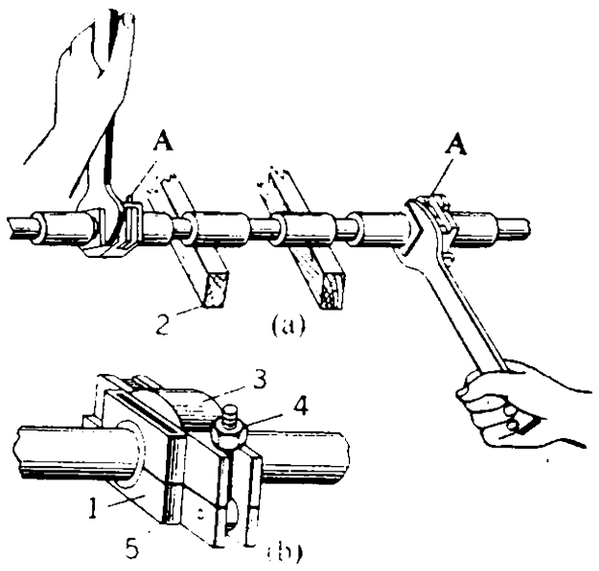


Fig. 80. Devices for disconnecting staffs of fluted rollers

Prior to starting the repair of fluted rollers, it is necessary to disconnect the staffs. This is achieved by means of a special wrench with three cover plates articulated together for the tight gripping of the surface of the roller staff. The roller staffs are disconnected directly on the frame by means of two wrenches. Figure 80*a* illustrates another device for disconnecting the roller staffs. Grippers *A* consisting of two halves *1* and *3* (Fig. 80*b*) are fixed from both sides of the point in which the staffs are to be disconnected. Each gripper has a lug with a saw-cut slit for the wrench. Both halves of the gripper are joined on the smooth necks of the rollers by a collapsible hinged bolt *4*. Next, the rollers are placed on special supports *2* (Fig. 80*a*) and using wrenches applied on the grippers *5* (Fig. 80*b*) the staffs are disconnected.

Straightening of bent rollers may be effected either manually (using a jimmy, sledge or straightening clamp) or by means of different devices which ensure a better quality and higher efficiency of repairs.

Figure 81 illustrates a machine for straightening bent fluted rollers. The roller *2* is placed on the supports *1* and *4* and imparted rotation at a speed of 80-100 min^{-1}. The rod *7* carries the bracket *6* with a straightening crank *5* having a bronze cushion. The crank is brought to the bent point of the roller and with a push by hand the spot is straightened out. During dressing, the roller may be stopped by simple shifting back the tension roller *8* rather than by disengaging the motor. The hook *3* placed on the non-working neck serves for retaining the rollers both on the supports and during straighten-

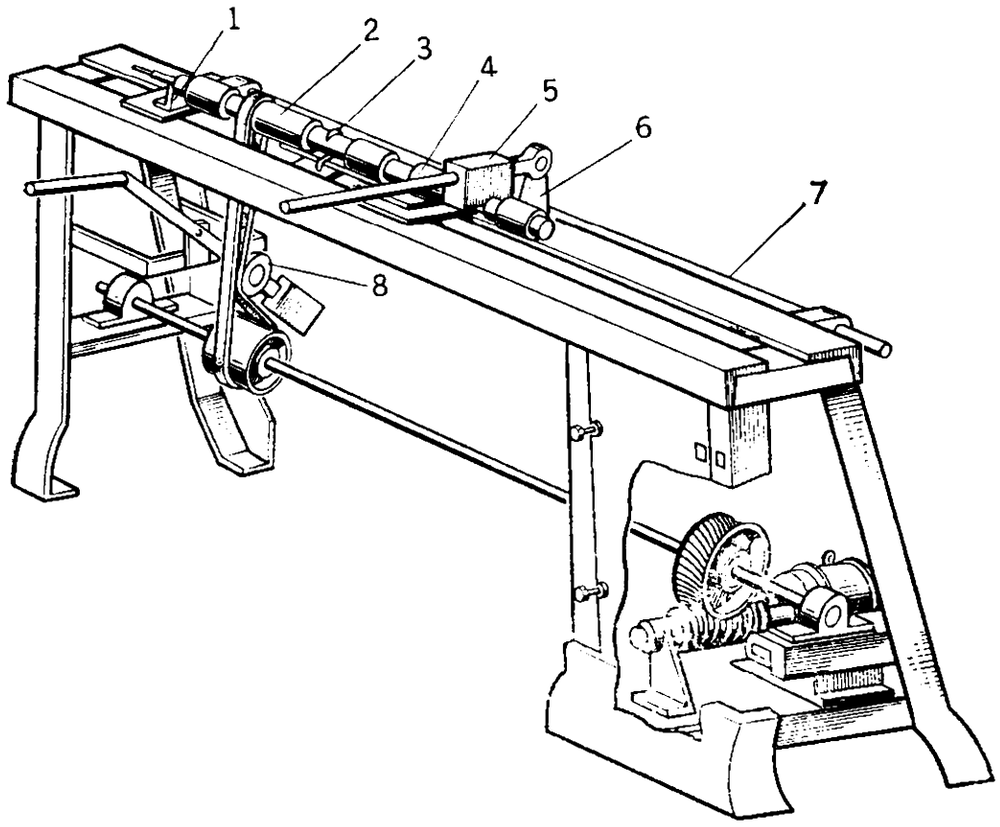


Fig. 81. Machine for straightening bent fluted rollers

ing. The hook and the supports may be shifted along the slot in the stand guides. The points of run-out on the cylinder are detected by an indicator and after straightening the run-out should not exceed 0.05 mm. The machine may be provided with a special screw press for straightening rollers with local flexure.

In some cases fluted rollers are straightened out directly on the spinning frame by means of a special device consisting of the claws *5* (Fig. 82), the traverse *3* and power transmission screw *2*. The claws are connected by the hinge *4* with the traverse. The thrust part of the power transmission screw has a collar step bearing *6* with a rubber damper. The claws are placed at both sides of the roller deflection so that the screw bears against its protruding part and by turning the crank *1* the deflection is gradually straightened out.

The restoration of worn roller necks may be effected by different methods. If the rollers have been subjected to surface hardening by high-frequency currents, or carburizing and hardening, the wear in diameter does not exceed 0.1 mm. In this case, the initial dimensions of the necks are restored by building-up in an electroplating bath with a coat of chromium up to 0.08 mm thick from each side. The necks of unhardened rollers are liable to have a greater wear (>0.01 mm) and therefore they are restored by building-up with electrodes or by metal spraying. The rollers may also be restored by applying a layer of polyamide material (capron) under pressure. Sometimes regrinding of worn roller necks is done to obtain a new size (repair dimensions),

and adequate bearing linings are chosen to suit the new dimensions. Also half-bushings turned and ground to the same dimensions are welded to the roller necks.

The method of restoring *a joint between the roller end and seat* depends on the wear of the joint. If it is inconsiderable, then the threaded parts of the end and seat are built up by copper deposition. After this, using a die and tap the thread is given the required dimensions, checked with gauges and a control unscrewing is carried out. In the event of great wear, the size of the seat is expanded to the repair dimensions (using a tap) and the worn end is built up with steel or brass. After boring the built-up roller end, a thread is cut to suit the repair dimensions of the seat thread. If the roller end is broken, it has to be built-up. For this, to ensure the centring of the built-up part, a hole is bored, reamed and threaded in the broken end of the roller after cutting it off. The built-up part is turned with an allowance in the diameter to permit finish of the assembly. The thread direction should be such that the joint cannot get unscrewed. The extension piece is screwed into the roller shell, turned, threaded and finally adjusted to suit the seat of the coupled staff. It should be taken into account, that the coaxiality of joined staffs greatly depends on the proper machining of the seat holes. When machining the holes, the operations are carried out in the following order: drilling the holes, boring the holes for the guiding neck, boring the holes for the thread, reaming the holes for the guide, chamfering and cutting the threading.

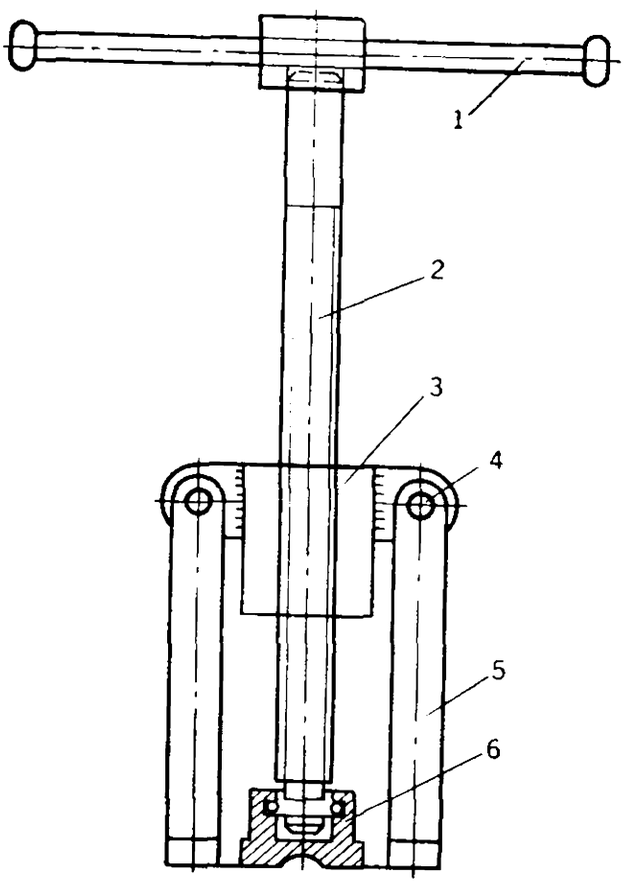


Fig. 82. Device for straightening bent fluted rollers

In some cases repairs are designed to increase and improve the longevity and service ability of the fluted rollers, for example, the use of split fast shafts in the first line of fluted rollers.

When repairing fluted rollers with deteriorated ends certain requirements are to be satisfied. The outside and inside threads must be made according to the third class of accuracy so as to permit easy unscrewing up to the half of the thread length. Thread stripping is allowed on not more than 1/8 of the circumference of one coil.

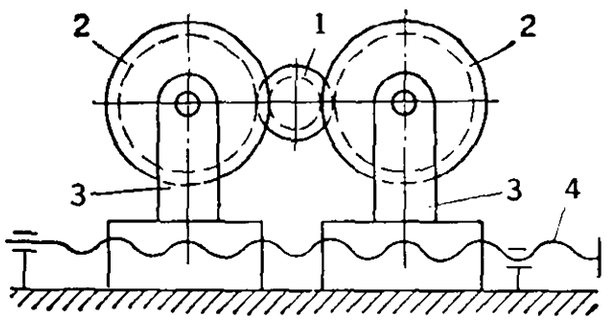


Fig. 83. Device for restoring roller fluted by knurling

The eccentricity of the thread must not exceed 0.15 mm and there must be no play at the points of connection. Local clearances should not exceed 0.25 of the circumference length and should not allow the passage of a feeler over 0.05 mm thick. In checking the roller staffs for rectilinearity, run-out, and twisting the allowable values should not be exceeded.

Rollers with *damaged fluted surface* are to be restored by roll forming, planing, milling, grinding and chromium plating. When restoring the rollers by roll forming or knurling, their surface is subjected to the pressure of one or several steel hardened rollers owing to which the metal is redistributed according to the profile of knurling rolls. This method may be used only for unhardened fluted rollers (middle and back rollers of drawing units in cotton spinning frames). Knurling is carried out by means of single- and multiroller devices minding that the latter ensure a better knurling of worn flutes.

Figure 83 shows the simplest device of this kind—a two-roll device mounted on a carriage. The roller *1* is fixed at the centres of the head- and tail stocks of a lathe. Two steel hardened fluted rollers *2* are freely mounted on shafts attached in movable stands *3*. Holes in the base of the stands are provided with oppositely directed threads through which the screw *4* with a right- and left-hand trapezoidal threads (corresponding to the stands) is passed. By turning the screw it is possible to bring together or to shift apart the stands with rollers or to clamp the rotating fluted roller between the rolls.

The rollers of drawing units in flax spinning frames are machined on a planing machine equipped with an automatic divider, or on a longitudinal milling machine by means of a shaped milling cutter.

To restore hardened rollers they must priorly be annealed and on restoring of the flutes they must be subjected to heat treatment. However, this kind of processing is costly and time consuming. For this reason, in such cases a flute planer is used with a divider and a grinding head attached in the planer stock.

At the restoration of fluted rollers made of stainless steel (for flax wet spinning frames) a double chromium plating is applied which allows a 30 to 40 percent increase in the rollers life and ensures an economy in expensive stainless steel.

The repaired fluted surfaces of the rollers must be clean and smooth (polished), without indentations, burrs, circular scratches and other defects; the dimensions and profile of the rollers must meet standards.

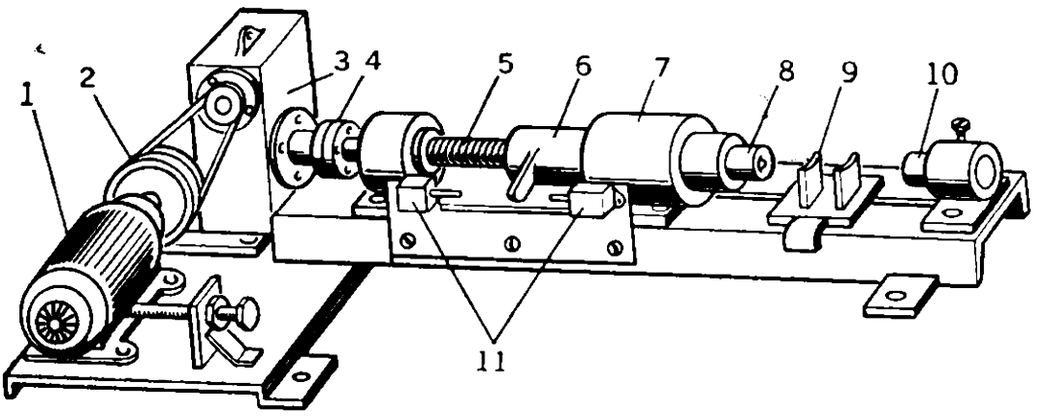


Fig. 84. Device for pressure fitting of elastic cots on top rollers

Top rollers. The wear of top rollers greatly depends on their design. Used in the drawing units of cotton spinning frames are solid top rollers with loose sliding friction bushings and antifriction bearings. Solid rollers present a high inertia and therefore their slippage is stronger (the drawing unit has couples consisting of a fluted roller and a top roller, which must rotate both with the same speed without slippage). The rollers with loose sliding bushings are better lubricated and they slip less than solid rollers. The rollers with antifriction bearings have a minimum slippage. At slippage the elastic cot of top rollers becomes worn more in the middle than at the edges, so that a worn top roller acquires a saddle shape. The rollers with worn cots are ground for restoring their initial cylindrical shape. The cots are replaced with new ones after multiple regrindings or on cracks appearance.

It should be kept in mind that when rubbing parts such as bushings, ball bearings and spindles are worn the top rollers also come out of order. The cots are made of rubber and their surface must be smooth, without scratches, cuts, scores and visible hard inclusions.

In cot regrinding the following operations are carried out: exterior examination; cleaning, washing and sorting; grinding (in assembly with the roller); checking for run-out.

If the roller cot is to be replaced by a new one, preliminarily the new rubber cots are checked to ascertain that they correspond to specifications. After changing the cot (using special devices) the rollers are run in assembly with metallic bushings and then sorted and checked for run-out. When choosing couplings (or cots) of synthetic rubber for press-fitting on top rollers it is necessary to take into account that the coupling stretch should not exceed 10-15%. Different devices are available for fitting the cots on the top rollers. One of them is illustrated in Fig. 84. The stand of this device carries the main parts: the power transmission screw *5* with the rod *6* screwed upon it, and the tip *8* provided with a helical spring. The rod has a stationary guiding bush *7*. At the right end of the stand there are

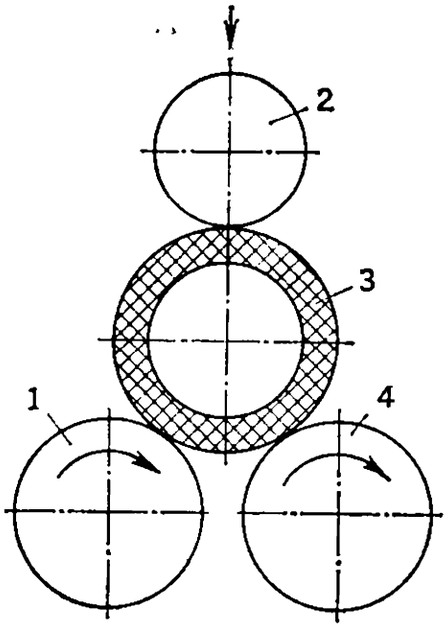


Fig. 85. Diagram of rolling top rollers with new cots

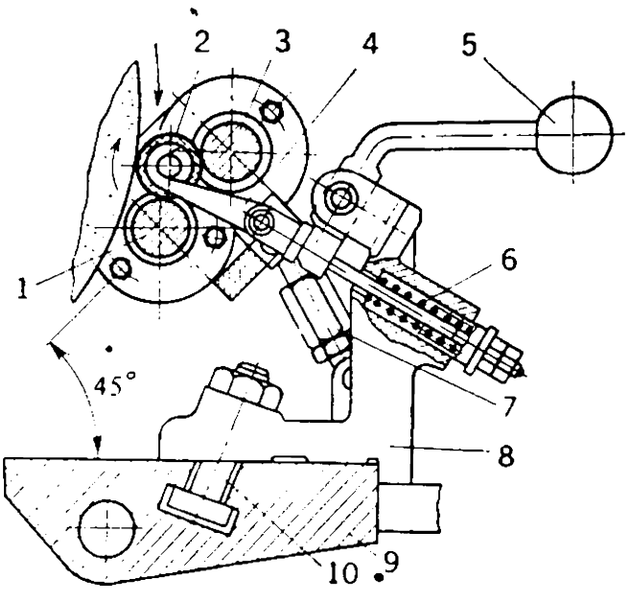


Fig. 86. Top roller grinding device

supports *9* and spring-loaded rest *10*. The screw is rotated by the electric motor *1* through the V-belt drive *2*, the reducer *3* and clutch *4*. The elastic cots or couplings coated with special glue are fitted from both sides on the roller which is placed on the supports after which the motor end switch is engaged. Next, the power transmission screw and further the rod with tip are put in motion. After pushing the cots on the roller the rod butts against the end switch *11* and automatically disengages the device. Automatic devices are also available for the replacement of the elastic cots on the rollers of spinning and roving frames. The most efficient among them is the automatic universal machine for replacing elastic cots of top rollers. The following operations are carried out in the machine: coating the inside surface of cots with glue, removal of worn cots from the bushing and putting on new cots.

Rolling of top rollers with new cots is effected in different devices and machines. Figure 85 illustrates this process. The roller *3* is placed between three rolls: the two bottom ones *1* and *4* being driving rolls and the top one *2* being the pressure roll.

Cot grinding is effected for imparting them a cylindrical shape and the required surface finish. The top rollers are ground in a circular grinding machine. Depending on the roller design, different grinding procedures are employed for machining the cots, i.e. centreless grinding is used for top rollers with antifriction bearings, and centreless grinding for rollers of other designs. For instance, rollers with cylindrical through-holes are fitted on special mandrels and centred by means of bevel bushings which are also pulled-on mandrels. Centres in which the mandrel with rollers is fixed, are inserted into the

front and back heads of the machine. Solid top rollers having no centre holes are attached in chucks inserted in the bevel holes of the front and back head spindles.

Figure 86 shows the device for centreless grinding of top rollers with antifriction bearings. The device body *8* is mounted on the swivelling frame *9* of the machine and attached by means of the bolt *10*. The driving roller *1* is actuated from the spindle of the front head. The top roller *2* to be ground is placed in the slot of the hook *4* for which it is necessary to push away the spring *6* by means of the crank *5*. A threaded connecting coupling *7* is provided for setting the driving roller *1* and supporting roller *3* in working position. The top roller to be ground rotates in opposite direction to the rotation of the grinding wheel. For grinding elastic cots flat grinding wheels are used; these wheels of straight profile, 250 mm in diameter and 32 mm in width are made of synthetic corundum of medium hardness and with grain size from 12 to 16. In grinding, the surface of the elastic cot must not heat above 80°C, as otherwise the structure and property of the rubber are badly impaired. For this reason, grinding is effected in two stages: first, coarse grinding leaving an allowance of 0.2-0.4 mm for further machining and next fine grinding. After grinding it is recommended to powder the roller with mica or other similar material. The roughness of the ground top rollers should not exceed 0.4-0.6 μm.

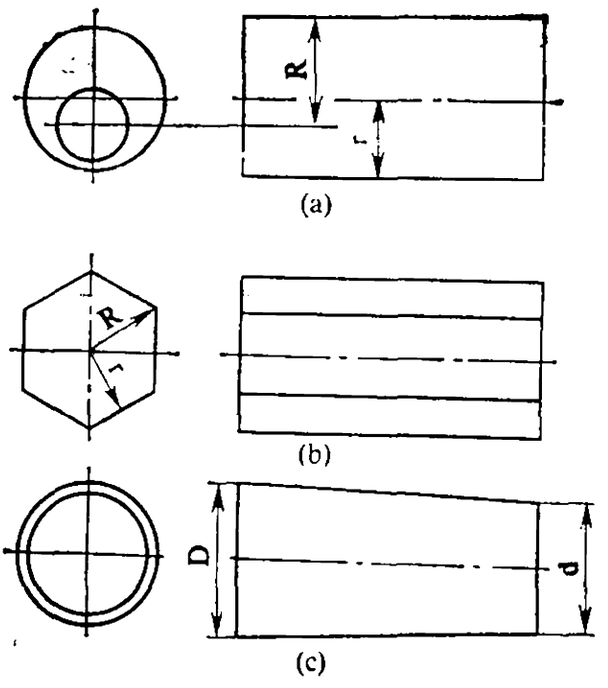


Fig. 87. Kinds of deviation in cylindrical shape of elastic cots

In the course of elastic cot surface grinding there might be deviations from the preset cylindrical shape and dimensions, i.e. eccentricity, faceting, and conicity. *Eccentricity* (Fig. 87*a*) is caused by the misalignment of the mandrel and worn centre holes. The allowable eccentricity for soft cots is 0.3 mm and for hard ones—0.02 mm. *Faceting* may be caused by an excessive pressure applied at grinding (Fig. 87*b*). The allowable deviations in radii *R-r* for soft cots is 0.03 mm and for hard ones—0.02 mm. *Conicity* results from the improper adjustment of grinders. It is especially evident on long cots (Fig. 87*c*). For fixed rollers the conicity in diameters *D-d* must not exceed 0.06 mm and for loosely rotating ones —0.04 mm.

To increase the service life the rubber and PVC top rollers should be turned. The top rollers of flax spinning frames differ in their design

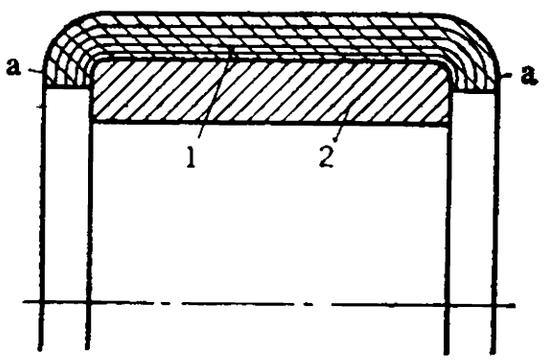


Fig. 88. Diagram of reinforced roller clothing of "arch" type

from the rollers of cotton spinning and other frames. For this reason their repair is carried out in a different way. At repairs the semi-ebonite disks are cleaned and the necks of shafts are turned and ground. Moreover, the shafts of the top rollers used in the drawing units of wet spinning frames are subjected to corrosion. When the semi-ebonite disks are completely worn they are replaced. In this event, the nuts are unscrewed, the deteriorated semi-ebonite disks are pulled off from the shafts, new disks are pressure fitted, the nuts are tightened and the disks are turned to required dimensions. Special machines are available for unscrewing and screwing-on the nuts, for removing deteriorated and fitting new semi-ebonite disks on the shafts. The top rollers with pressure-fitted semi-ebonite disks are turned and flutes are knurled upon them. The width and diameter of disks must be constant and the same for all disks.

Rubber cots for top rollers of drawing units as compared with PVC cots present a greater elasticity, are less apt to changes with time and therefore their useful life is longer. Yet, the working surface of rubber cots has a great deal of microirregularities which results in the increased number and breakage rate of windings of the front roller of the drawing unit.

The surface processing of elastic cots reduces the surface irregularities and consequently improves the operational features of the cots. On heat treatment of elastic rubber cots, their surface layer becomes smooth and glossy. The optimum conditions for thermal treatment of rubber cots are: a temperature of 300°C and time of treatment—10 s.

A method has been developed for the thermomechanical treatment of elastic cots by a progressive increase in the temperature from 200 to 400°C. In this case, the coated rollers are rolled between plates for 25-35 s on the machine at different heating temperatures. The use of cots subjected to such heat treatment increases their life by 30%.

Reinforced cots are used for heavily loaded drawing units. The combination of reinforcement with interference fit ensures a more reliable fixing and smaller deformation of the rubber coating. Figure 88 shows schematically the reinforced coating of the "arch" type. Serving as a reinforcing element the cord thread helically runs inside the coating *1*, which is placed with an interference fit on the top roller *2* with an overlap *a* at the edges. The useful life of such coatings is twice as that of usual ones.

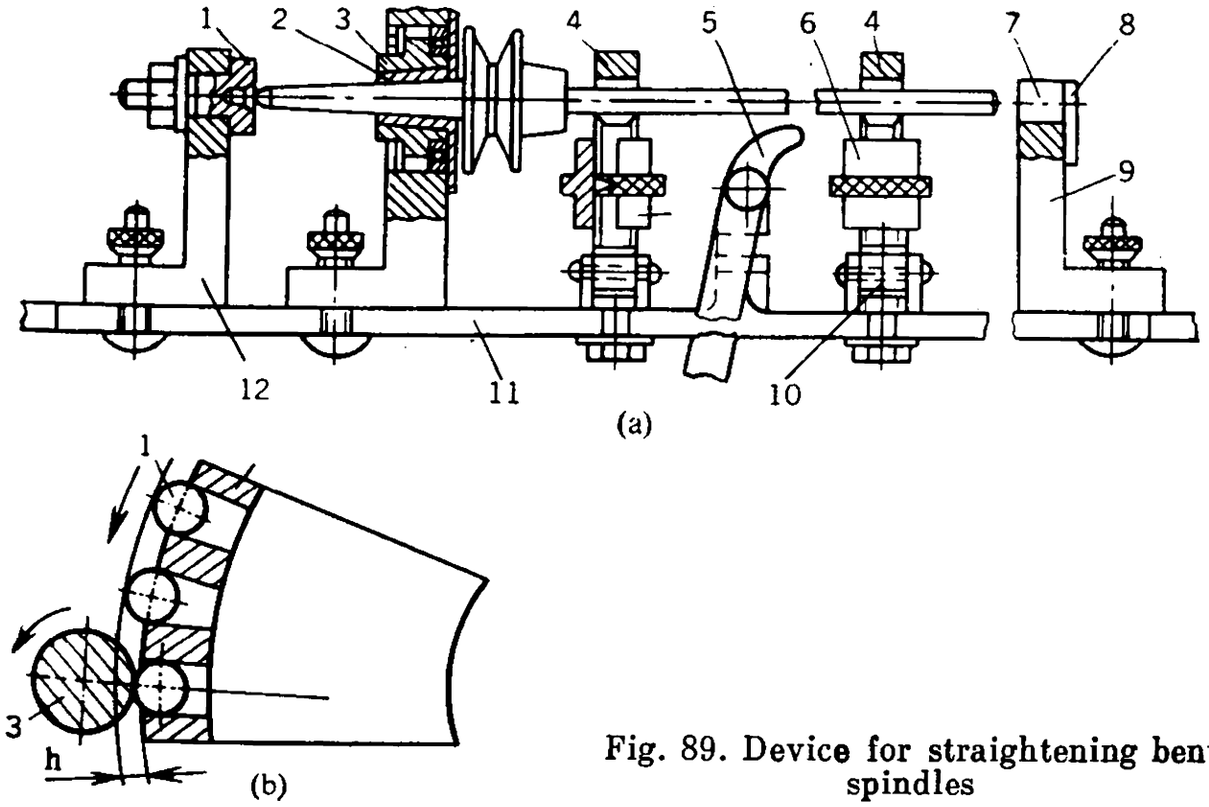


Fig. 89. Device for straightening bent spindles

SPINDLES. The rotational speed of spindles in spinning frames of different designs reaches 15 000 min^{-1} and more. For this reason the main requirement set towards the spindles is the absence of strong vibrations leading to an increase in yarn breakage. In the course of operation, the following disarrangements may be observed: residual deflections of spindle blades, wear of rubbing surfaces and spindle breakage.

Bent spindle blades are repaired by straightening. To begin with, the point and amount of deflection are determined. For this, the spindle blade is placed on knife edges or fixed between the centres of the lathe, after which the spindle blade is turned around its axis and the point and amount of deflection are determined by means of an indicator. Straightening may be effected either manually by means of a hand press and copper hammer or by employing different special devices. For straightening bent spindles the so-called static method is used, while for straightening spindles with an inconsiderable residual deflection the dynamic method finds application.

In Fig. 89*a* a universal device is illustrated designed both for static and for dynamic straightening. In the case of *dynamic* straightening a split bevel bushing *2* is fitted on the spindles. Then together with the spindle the bushing is inserted into the bearing with a conical hole *3*. The spindle foot bears against the footstep *1* attached on the movable stand *12*. Next, the motor is engaged imparting the spindle rotation with a speed of 3000-4000 min^{-1}. The spindle is straightened by turning the lever *5*. *Static* straightening using the

device is carried out as follows. The stand is shifted into the slot disposed at an angle of 90° to the longitudinal slot *11*. The spindle rests on the footstep, the bed *7* and strap *8* attached in the prismatic movable stand *9*. From both sides of the point of maximum deflection, collapsible hooks *4* are provided which are articulated by means of hinges pressed to the spindle by the nut *6*; between the hooks there is the lever *5* which presses on the delivery part of the spindle. The precision of straightening is checked with an indicator. After straightening the hooks are pushed aside on the hinges *10* to release the spindle.

In the event of mass repair of spindles, the bent spindle blades are straightened out using a more efficient method of cold work obtained by reiterated pressure exercised by balls on the spindle, which are pulled out by centrifugal force. The balls *1* (Fig. 89*b*) are arranged radially at a regular distance on the edge of the disk *2* and may move in seats, on disk rotation, each ball rolls out and hits the spindle *3* and rebounds. Here the rotation of the disk is combined with the rotation and longitudinal displacement of the spindle. Therefore, the balls hit each time a new point of the spindle. The straightening process may be adjusted by modifying the rotational speed of the disk and spindle, the diameter and number of balls, the amount of longitudinal feed, the number of passages and the interference fit, i.e. the amount of positive rejection of the ball by the spindle. This method of spindle straightening ensures a sufficiently high accuracy of the operation (up to 0.01 mm in the run-out). The finish class of a cold-worked surface is 1-2 classes higher than that of a ground surface.

For repairing **worn spindles** the following methods are used: regrinding, chromium plating, metal plating, building-up, as well as mechanical methods of repairing and restoring with polymer materials.

Most often the wear of spindle heel results in deformation of its shape. The spindle with a worn heel is *reground* by means of a special device or on a machine using intensive cooling.

In *chromium plating* the surface of worn-out spindles is prepared for the job of grinding on a circular grinder. Next, the spindles are mounted on a suspension, degreased, chromium plated, washed, neutralized and taken off from the suspension. Provided the spindle surface has been thoroughly prepared for chromium plating no further machining is required after plating.

When repairing spindles by *metal spraying* the following work is to be done. The worn out surfaces are turned on a lathe and sand blasted, then the spindles are fixed on the lathe and metal sprayed by means of an electric arc or gas-flame metal sprayer attached on the lathe carriage. During metal spraying the spindle is imparted rotation while the carriage with a metal sprayer effects a longitudinal trans-

latory motion. The spindle with the sprayed metal layer is turned on a lathe and ground.

Big and heavy spindles are restored by the *building-up method.* Prior to building-up the spindles are annealed in a furnace for several hours at a temperature of 740-760°C and left in the same furnace for cooling. After cooling, a small layer of metal is removed with a cutter so as to obtain the required thickness of the built-up layer (1-2 mm). Building-up is carried out by the gas-flame method using a neutral flame by means of a burner of reduced power (by 1-2 Nos.). The built-up spindle is forged, roasted and machined on a lathe leaving an overlap for grinding of 1-1.5 mm taking into account the possibility of strong warping at the subsequent heat treatment (hardening and tempering).

In some cases, to repair worn-out spindle heels different mechanical methods are applied, including the replacement of heels (skeleton spindles). If the hole in the spindle stem has distorted dimensions and shape, it is primarily reamed and then a ground heel is pressed in. To avoid the violation of centring the heel is finally ground in assembly. Worn large-size spindles are sometimes restored by regrinding to repair dimensions. In this case, the bearings are set for the new dimensions of the spindle. Damaged wooden sleeves for tubes are restored by means of polymer materials. First, the damaged part of the sleeve is turned to obtain a circular groove and then the spindle with the groove is placed in a special mould which is filled with melted capron. After the capron has hardened the worn-out place is restored and the spindle is ready for use.

Broken spindles are repaired only when there are no spare spindles available at the mill. The repair is effected by electric-butt, arc and gas welding. Prior to electric-butt welding, the broken spindle is annealed and then cut for obtaining a proper shape in the broken part. A steel blank is produced with an allowance of 5-7 mm in length for partial melting and burning at welding and of 3-4 mm for machining after welding. The workpiece is turned with an allowance of 1.5-2 mm for the machining of cylindrical surface after joining. The spindle is welded on an electric-butt welding machine with a power depending on the diameter of the spindle to be repaired. If no such machine is available, the spindles are restored by manual electric-arc or by gas-flame welding. Prior to welding, the spindle is again annealed and the ends to be joined prepared for welding. To ensure a good coaxiality and to reduce the possibility of warping, welding is carried out in jigs which are made to fit the dimensions of the repaired spindles. After welding, the spindle is annealed, dressed, turned, and ground according to required dimensions.

The technical requirements set towards the spindle after repairs are: sufficient elasticity and absence of residual deformations; vibra-

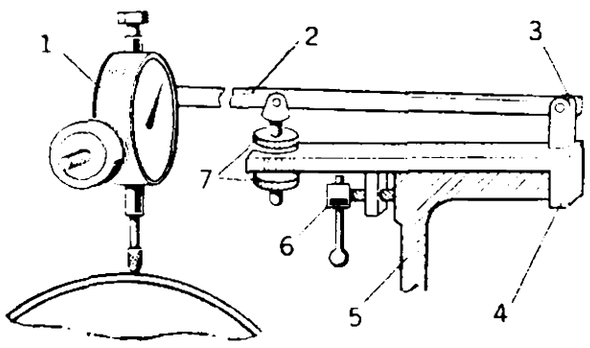


Fig. 90. Drum run-out indicator

tions should not exceed allowable values (the run-out of the spindle blade should not exceed 0.06 mm at the top of the sleeve); sufficient resistance to wear; strict correspondence of design dimensions to standards; absence of exterior defects, cracks and others.

TIN DRUMS. Intended to transmit the motion to spindles and consist of a rigid shell,* tin diaphragms and cast-iron flanges (sleeves). In the course of operation, the tin drums are liable to develop the following defects: the vibration, dents on the tin shell, fractures and opened seams, chipping and cracks on the cast-iron flanges, and spindle wear.

The vibration (run-out) is determined directly on the spinning frame by means of an indicator (Fig. 90). The watch type indicator *1* is fixed on the rocker *2* with a hinged support *3* arranged on the bracket *4*, which is provided with an adjusting screw *7*, nuts, and a stop screw *6*. The instrument is fixed as a C-clamp on the spindle rail *5* of the spinning frame. The indicator is set by means of the adjusting screws strictly on the vertical line passing through the centre of the drum which is manually rotated. If the radial run-out of the drum does not exceed 0.7 mm, it may be considered fit for operation.

All other defects are detected by inspection and if it proves necessary the drum is repaired in a special shop. Prior to starting the repair, the tape is removed from the tension roller, as well as 4 or 5 spindles disposed opposite the intermediate bearings of the drum. Next, the back board of the frame is removed and using a wrench the connecting bolts of the drum are unscrewed taking care to support the line of drums during this operation by means of a special truck-jack. The line of drums is separated in sections by a pinch bar which is placed between the drums or by means of a special separating device. The drum spindle is extracted by a puller (Fig. 91*a*, *b*). The puller is fitted with its conical split bushing *3* on the free end of the spindle, and using the screws *1* passing through the traverse *2*, the puller is pressed against the drum flange. When the screws are tightened, the conical bushing grasps the spindles and draws it out of the drum. The main shaft is extracted from the head drum by means of the puller illustrated in Fig. 91*c*. The dismountable traverse *3* with removable inserts *4* is attached on the shaft by the tie *2*. The shaft is tightened by two power-transmitting screws *1*.

* For wet spinning frames the drum shells are made of tin plate.

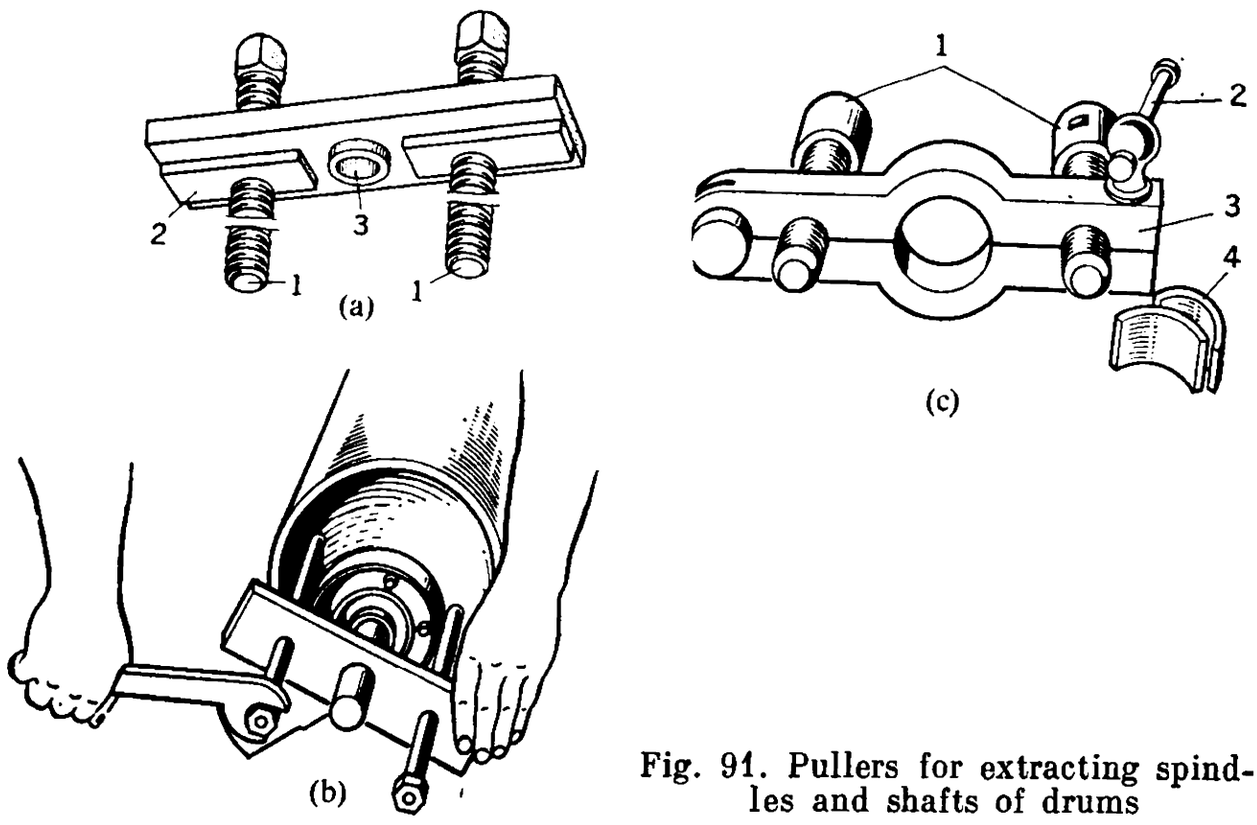


Fig. 91. Pullers for extracting spindles and shafts of drums

Depending on the kind of fault, the repair of spinning frame tin drums involves the following work: dents are flattened, the seams are resoldered, some members are replaced, broken flanges and spindles are restored. The drums should be balanced after repairs.

Dents are straightened out manually (using a hammer, a soldering lamp (blow torch), and mauls) or by means of other devices. For instance, the device shown in Fig. 92 has two wooden or plastic blocks *1* tied together by a frame *4* of angular iron. In the frames slots are provided along which the traverse *5* connected by the screw *2* is moving. A screw passes through the nut *3* attached in the frame crosspiece. The hook *6* is attached to the traverse. The device is placed with its wooden blocks on the butt joints of the drum members; the hook foot is soldered in the middle of the indentation and turning the screw the hook is raised; simultaneously the edges of the indentation are flattened with a wooden hammer.

Resoldering seams is done in the case where the seams have become opened or broken in the course of operation. The point of soldering is cleaned with a file, emery cloth or by any other method and the member is tap-soldered in several points. After careful checking on the machine the whole seam is preliminarily coated with flux and soldered. To avoid the deformation of the drum, each quarter of the circumference should be soldered, alternating the operation in diametrical direction. Cross-seams are reinforced by additional soldering through holes drilled in the top sheet of the shell. The distance between two holes should not exceed 75 mm. The diaphragms are tightly fitted to the drum and soldered to its shell. The clearance

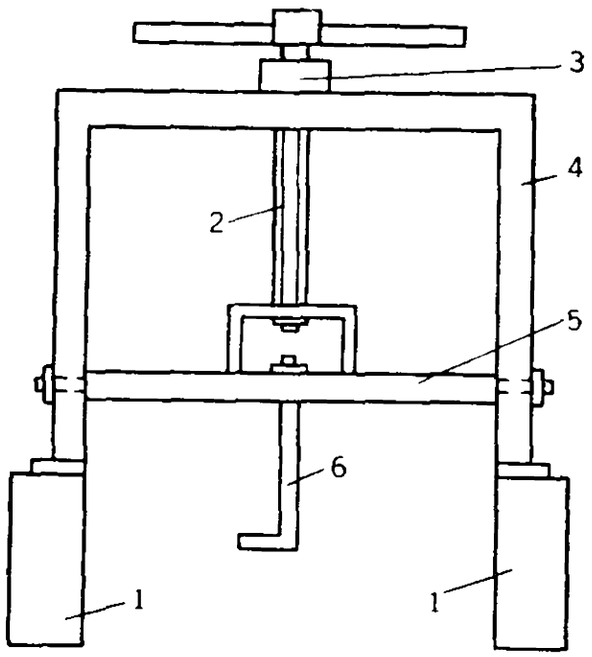


Fig. 92. Device for straightening tin drums

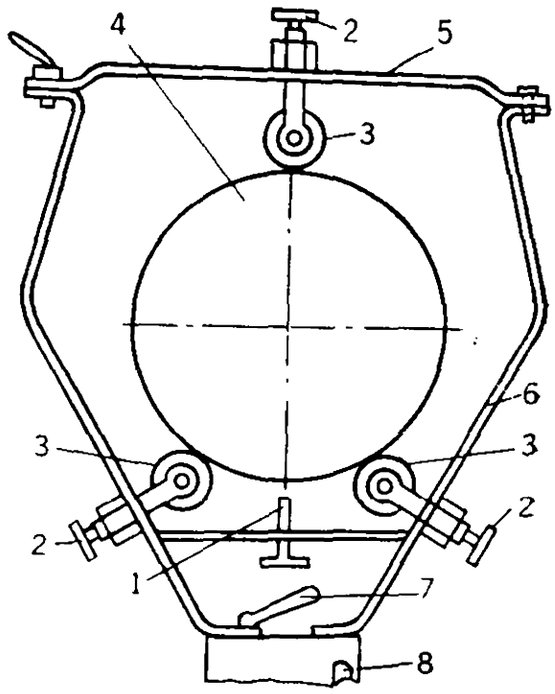


Fig. 93. Straightening steady rest

along the circumference should not exceed 0.2 mm and should not appear more than in three points. The length of the clearance should not exceed 25 mm.

When soldering the cast-iron flange to the drum shell, the point of soldering should be preliminarily prepared. Soldering is done flush with the drum surface taking care to obtain an even and clean seam. Adjacent flanges (of the head drum) are soldered so as to obtain the keyways on the same straight line. (The allowance for displacement is not to be over 0.2 mm.) In terms of economy welded seams may be used taking into account their high strength. However the repair of such drums is a complicated job and their overhaul becomes practically impossible. Therefore, a special device (Fig. 93) is used for simultaneous straightening and resoldering of drums. This device is made as a steady rest comprising a steel frame *6* (the frame upper brace *5* is collapsible) provided with three straightening rollers *3* (bearing balls).The rollers may be displaced in radial direction by means of the screws *2*. In the bottom part of the steady rest there is provided a micrometric screw *1* which serves to check the vibration of the drum. The steady rest is mounted on a balancing machine and may be displaced along the guide of the machine *8* and fixed at the required point by the stop screw *7*. The drum *4* fixed in the balancing machine and passed through the straightening steady rest is slowly rotated and the point of soldering is uniformly heated along its circumference. Next, by turning the screws *2* the roller is brought to this point. The drum heated at the point of soldering is easily straightened by the rollers. The straightened point is cooled and

soldered. All the other seams are straightened and soldered in the same manner. Next, the drum dynamic balancing is carried-out in the same device. The aforementioned device ensures sufficiently accurate soldering so that the drum run-out (vibration) does not exceed 0.7 mm. Recently the method of drum glueing with synthetic glues has found application.

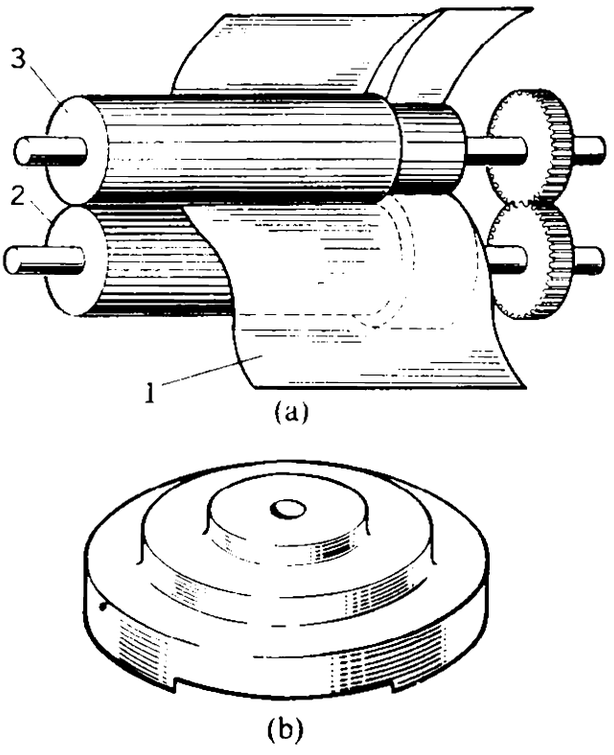


Fig. 94. Rolls and pressure mould

If the repair of a damaged drum is unfeasible, the drum members are replaced by new ones. In this case, the old member is eliminated, while the new one is soldered and welded. When spare members are not available, they are produced in the shops of the textile enterprise. A blank is cut-out from a sheet of tin plate *1* (Fig. 94*a*) in accordance with the dimensions of the member, and passed between the rollers *2* and *3* to impart it a cylindrical shape after which the ends are flanged. Further, the seams are soldered and welded with overlapping (in a spot- and seam welding machine) and carefully dressed. Ready members must engage each other without play. The reinforcement diaphragms are made of the same material as the drum shell. The diaphragm blank is cut out of a sheet and extruded by means of a pressing mould (Fig. 94*b*) attached in the spindle of the lathe. After the extrusion of diaphragm contour, its edges are flanged.

In the course of operation the shank (hubs) of the flanges made of gray cast iron may get broken, and the chipping of the rims might occur. Repair of flanges with broken shank is carried out in the following manner: the shank is cut off, holes are bored, a fine thread is cut in the sleeve cup, a new shank is screwed in and welded. The assembled flange is attached on the lathe, the shank is turned to definite dimensions, a hole is made for the sleeve, and using a milling cutter (a lathe cutter or a saw) a slit is made. The new shank (hub) may be attached to the flange also by six bolts. The flanges with chipped rim are surfaced and then turned on a lathe. If the flange has no other defects except the chipped rim, it is repaired without being separated from the drum. In this case, a kerf is made at the chipped points of the rim on the circumference of the flange, a dovetail groove is sawn and an insert is put into this groove and

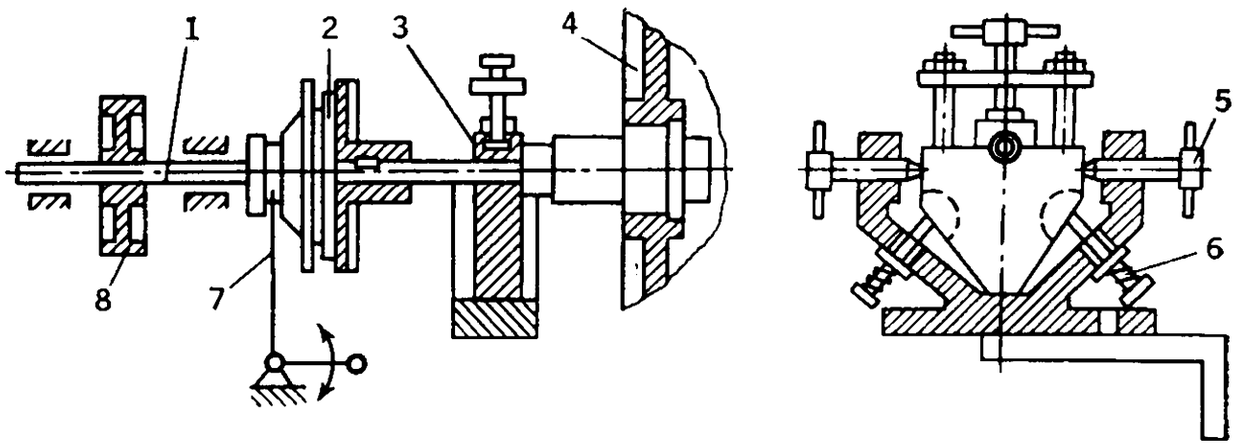


Fig. 95. Machine for dynamic balancing of tin drums

soldered. Prior to their installation on the drums, the flanges are subjected to balancing.

The head and off-end spindles of the drums come out of order due to the wear of rubbing surfaces. In this case they are repaired as axles and shafts.

Special attention in the repair of drums should be paid to balancing (static and dynamic).

Static balancing of drums is carried out on knife-edges. The drum is set with its spindles on the knife-edges and rotated manually. If the drum is not properly balanced, its heavier part always comes to occupy the bottom position. In this case, a recess is made on the opposite side of the drum and filled by soldering with lead until the drum is statically balanced. Next, the *dynamic balancing* of the drum is carried out in a special machine (Fig. 95). The drum *4* is placed with its spindles on two split bearings *3* having a prismatic base. One half of the coupling *2* is fixed to the end of the spindle and the second by means of a sliding key—on the driving shaft *1*. Next, the motor is engaged to impart rotation to the drum through the pulley *8*. Then the coupling is disengaged by the crank *7*, i.e. the motion is not any more transmitted to the drum which continues to rotate by inertia. At the same time, one of the bearings is released from rigid fixing (the bolts *5* are loosened). If the drum is not properly balanced the released bearing deviates from initial position and causes the deformation of the spring *6*. The heavy part of the drum which has provoked this deviation is marked with chalk. A recess is made on the opposite side of the drum to be filled with lead to achieve drum balancing. With this aim it is possible to use a rubber tyre which is fitted on the drum. After determining which of the drum sides is heavier, a weight is placed under the tyre at its opposite side. By displacing the weight and changing its mass the necessary solder mass and points of soldering are determined. Further, all the soldered points are carefully dressed. Balancing is done at high rotational speed of the drum (10% higher than the working rotational speed).

The deviation of the repaired drum diameter after assembly and balancing from the nominal one should not be more than $\pm 0\ 5$ mm, and the deviation from rectilinearity of the drum generatrix at its installation on the axles as well as the radial run-out should not exceed 0.7 mm (the run-out is checked at the flanges and diaphragms, i.e. in the rigid parts of the drum). The exterior surface of the drum should be smooth, without burrs and indentations. Small dents with a diameter not over 20 mm and a depth not over 0.5 mm are allowable, but in a number not more than five indentations per section.

TENSION ROLLERS. Ensure a regular tension of the tape in the drive from the drum to spindles. In the course of operation certain defects may appear on the roller rim made of tin plate or thin galvanized steel and on corrugated washers of tin plated or galvanized iron 0.7-1 mm thick, such as indentations, wear of hardened steel shaft and bearings (sliders), loose fastenings, hook wear, etc. When repairing them, the tension rollers are disassembled, dressed and assembled.

In disassembling the roller, the nuts are unscrewed, the shaft is drawn out, and the rim is flanged. A special device shown in Fig. 96*a* is used for unscrewing the nuts. The shell *6* mounted on the bear *7* is provided with a recess corresponding to the profile of the tension roller. The roller is placed in this recess so that the bottom nut is in the hexagonal hole of the change plug *4* and is centred with three screws *5*. The socket wrench *3* attached on the rod *2* is placed on the top nut of the roller, and turning the crank *1* this nut is unscrewed. Then the roller is ejected by the pusher *9* using the crank *8*.

When it is necessary to straighten out the rim or disks of the roller, the latter must be flanged and one part must be separated from the other. For this, the device shown in Fig. 96*b* is used. The roller with its shaft removed is placed into the recess of the shell *7* in which the pusher *6* with head is inserted. The profile formed by the head together with the recess bottom corresponds to the profile of the roller disk. At the end of the rod *3* there is a pin *4* which passes through the hole of the roller and is driven into the pusher threaded hole, thus fixing it in the device. Mounted freely on the rod is the bushing *2* carrying the holder *1* with wrench *5* for flanging the roller. The wrench is retained on the holder by means of a bolt round which it may freely turn along the arc of the roller circumference which allows the adjustment of the cutting blade feed during flanging. The cutting blade of the wrench is ground wedgewise in the shape of an oval so that its pointed end penetrates under the edge of the rim flange, while the back part of the wrench by bending the flange straightens it in vertical direction.

This done, the roller is started to be straightened out. The crushed rim is straightened out in a device operating on the rolling principle

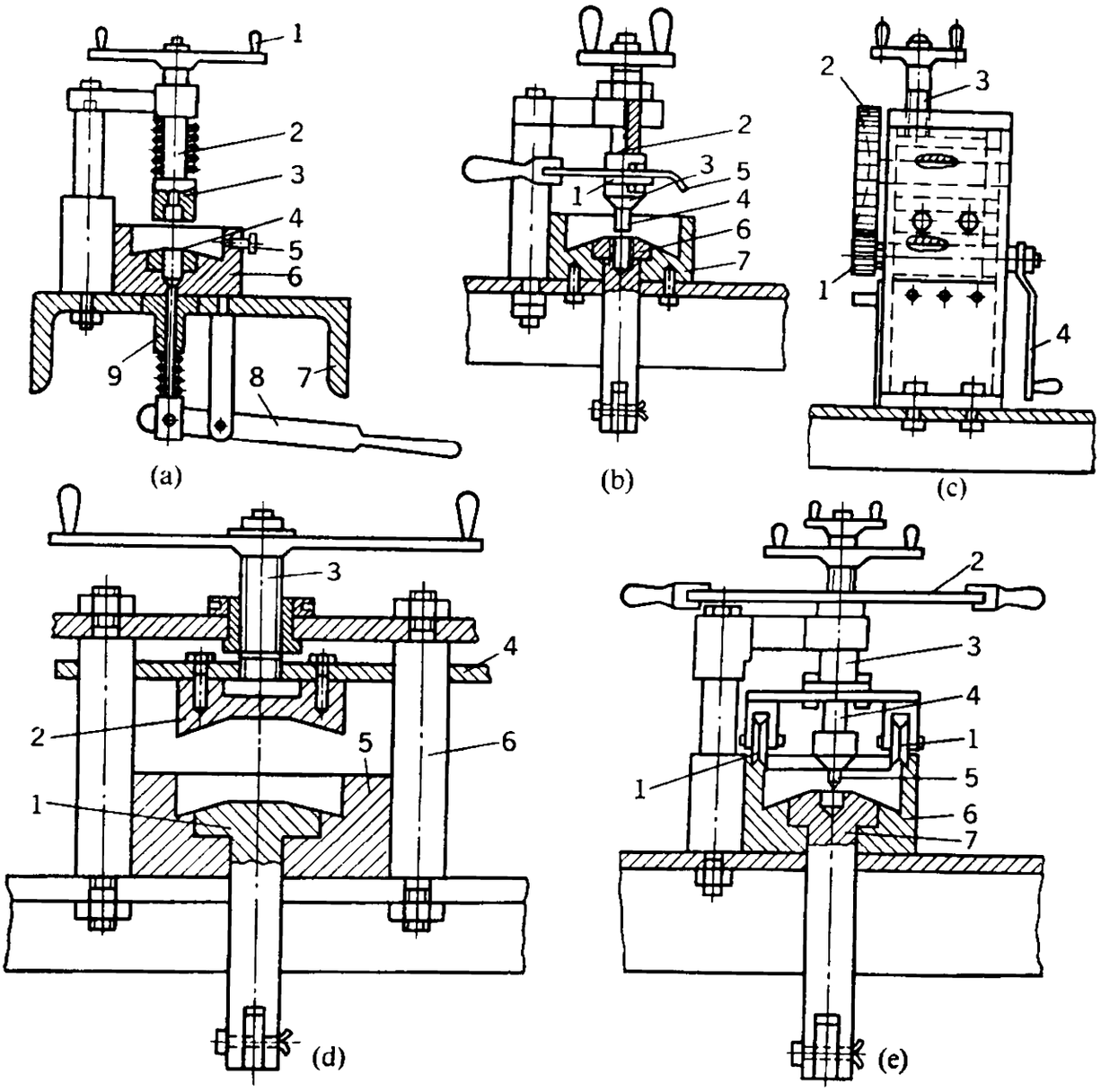


Fig. 96. Devices for repairing tension rollers

(Fig. 96*c*). Steel hardened rolls *1* and *2* rest in bearings; the top roll *2* slides on the shaft, while the bottom roll *1* is stationary. A recess provided at the butt of the top roll serves to accommodate the protrusion of the roller half to be straightened. The roll diameter corresponds to inside diameter of this roller half. The clearance between the rolls is adjusted by the screw *3* serving to raise or to lower the upper roll. The crushed rim is placed between the rolls *1* and *2* which are brought together with the screw *3* thus pressing the rim wall. Using the crank *4* the roll *1* is turned and by friction the rim and roll *2* are rotated. The rim is straightened and acquires a correct cylindrical shape. Crushed corrugated roller washers are straightened in a press tool (Fig. 96*d*) comprising a die *5* with a pusher *1* and a punch *2* attached to the traverse *4*; the latter can be displaced along the guiding columns *6* by means of the screw *3*. The roller

half with the crushed washer is placed in the die and using the screw *3* the punch is pressed, and as the die and punch have the shape corresponding to the washer profile the latter acquires the necessary shape. After straightening the workpiece is ejected by a pusher using the crank.

The assembly of the roller halves after straightening is effected manually. Then the rim flange is crimped in a special device (Fig. 96*e*). The roller halves are inserted in the seat *6* and the pin at the end of the rod *4* is passed through the hole of the assembled roller and screwed into the hole of the pusher *7*. The pin tightly presses the halves of the roller so that the flange of the exterior roller half protrudes by 1.5-2 mm. When the bushing *3* with the crank *2* is turned the rollers *1* placed on the rim flange cause its rolling-up. To crimp the flange, the crank must be turned several times. The quality of rolling-up depends on the shape of the rollers. It is efficacious to use one conical roller and one double-flanged roller. After rolling-up the roller is ejected with a pusher. Then the shaft is inserted and the roller is balanced in assembly.

In the case of inconsiderable wear (less than 0.3 mm) *shafts* are restored by chromium plating, but in the event of heavy wear they are surfaced by spraying or built-up. Frequently worn-out shafts and bearings are replaced by new ones. Worn *hooks* are restored by using capron bushings. Cotton or capron tape is used as a flexible drive. The longevity of the cotton tape is two months and that of capron tape is two or three times longer. Capron tape is joined by glueing and applying electrical heated tongs. To avoid slippage of the capron tape, the shape of the tension roller is modified by knurling two folds at its butts. Sometimes the tension rollers may get out of order to the loosening of the bolt fixing the tape holder. In the course of operation the tape holder is pressed to the tension roller whose wear is caused by rubbing. To avoid this trouble, the tape holder fork is provided with a limiter protecting it from contact with the tension roller and thus ensuring a considerable increase in the useful life of tension rollers.

Open-End Spinning Frames

Lately high-efficiency open-end spinning frames of the БД type have acquired a widespread use. These spinning frames are available in different modifications. The most typical one is the open-end spinning frame БД-200Р with a spinning head spacing of 200 mm. This spinning frame is intended for producing cotton yarn with a linear density of 62.5-15.4 tex and yarn with a linear density of 50-20 tex from synthetic and man-made fibres 40 mm long.

The spinning frame БД-200Р consists of the yarn delivery mechanism, the headstock and tailstock gearings, the yarn draw-off ar-

rangement with traverse, the building mechanism, the mechanism for threading adjustment and the spinning heads.

For preparing the frame to be repaired it is cleaned from wastes and rests of semi-finished products. Repairs should be made strictly according to the schedules. In some cases the centrifuges of the spinning frame БД-200 are repaired on stands.

Medium repairs are carried out every three months and involve: checking the arms of the building mechanism, the centrifuges (with partial dismantling), the delivery mechanism and yarn traverse with the replacement of faulty parts and units; the adjustment of the severing knives of the reserve bunching mechanism, the inspection of all tension and guiding rollers and the replacement of faulty ones; checking of all belts and the replacement of worn-out ones; checking the fastenings of electric equipment and all other units and parts.

The complete overhaul of the spinning frame is carried out once a year. All the main units with the exception of the stand are completely disassembled; the all broken and worn-out parts and units are replaced. If necessary the stand is also checked and readjusted.

Characteristic troubles in the unit of the spinning frame and methods of their elimination are given in Table 4.

Special fitter's shops are provided at the mills for repairing the spinning heads of spinning frames БД-200. Every fitter in the shop has a specially equipped bench with an electric instrument for checking the sensor and the centrifuge as a whole. Mounted on the bench are pivotable mechanisms for installing the centrifuges in any required position, and plug sockets are provided for connecting vacuum cleaners and soldering irons. The bench has a drawer for keeping tools in it. The working posts have pullers for extracting rotors from centrifuges as well as different tools, soldering irons, gauges and indicators.

Every shop has a work bench provided with vices, tables and a tester for accurate checking of the centrifuge electrical parts. The efficient cleaning of centrifuges is ensured by vacuum cleaners and the tables are equipped with a system for the removal of contaminated air and dust. The centrifuges are transported from the spinning frame to the shop in three-deck trucks accommodating up to 50 spinning heads. Multi-deck racks are available for storing 600 spinning heads.

The periodicity of centrifuge repairs in the case of the spinning frame БД-200 is as follows: overhaul—every year (duration—five days); medium repair—every six months (duration 2.5 days); thorough cleaning—every three months (duration one day). At thorough cleaning the spinning heads are cleaned and checked directly on the spinning frame.

Spinning heads and drawing-off shafts. The majority of disarrangements in open-end spinning frames are due to spinning heads. The

Table 4. Main Faults in the Open-end Spinning Frame

Description of faults	Causes	Method of elimination
	Feeding Mechanism	
Sliver breakage in funnel	Accumulation, thickening, or contamination of sliver	Elimination of sliver defectuous part
Frequent sliver breakages in funnel with tip pointing	Funnel is out of order	Replace funnel
Feeding roller does not rotate, though coupling is engaged (sliver is not fed to spinning head)	Jamming of feeding roller neck Improper operation of coupling	Remove roller and clean it Clean coupling and with a feeler set a clearance of 1 mm between magnet and flange
Feeding roller rotates when coupling is disengaged (sliver is fed in spinning head)	Sensor fails to engage coupling	Using a feeler est a 1 mm clearance between magnet and flange. Clean and adjust sensor
Frequent yarn breakages	Inadequate table pressing effort	Using a dynamometer adjust table pressing effort to 24±1.5 N
	Sensor	
Carrier is in extreme L.H. position, sliver is not fed and lamp does not burn	Lamp is burnt	Replace lamp
Carrier is in extreme L.H. position, sliver is fed and lamp burns	Coupling electromagnet is out of order	Replace electromagnet
Carrier is in extreme R.H. position, sliver is fed, lamp does not burn	Coupling electromagnet is out of order, electric circuit is broken, improper adjustment, lamp is burnt and hercon is out of order	Replace electromagnet, restore electric circuit, replace lamp and hercon (reed relay)
Carrier is in extreme R.H. position, sliver is not fed and lamp burns	Hercon is out of order	Replace hercon

Table 4 (*continued*)

Description of faults	Causes	Method of elimination
Carrier disengages in two positions	Hercon is rather sensitive, because of too small clearance between contacts	
	Fibre Separation Mechanism	
Fibre is not fed into centrifuge	Fibre winding on circumference due to damaged fillet	Repair fillet or replace combing drum
Combing drum does not rotate or rotates at reduced speed	Clogging of space under or above combing drum	Proceed to cleaning
	Improper installation of combing drum	Using a template set a distance of 1.5±0.3 mm from top surface of spinning head to combing drum
Irregular fibre feed	Burrs or scratches in connecting canal	Proceed to dressing
	Point of separating knife is damaged	Ditto
	Accumulation of fibres under separator	Eliminate accumulated fibres
Accumulation of fibres under separator	Damage of separator	Repair or replace separator
	Badly contaminated product	Replace sliver
	Centrifuge	
No threading	Clogging of air discharge or labyrinth	Proceed to cleaning and setting centrifuge for size of 10.4 mm
	Rotational speed of centrifuge is too low	Proceed to cleaning and setting centrifuge for size of 10.4 mm, see that belt is pressed to centrifuge pulley
Noise	Collecting surface is damaged	Replace centrifuge
	Faulty bearing	Ditto
	Collecting surface is contaminated with grease	Carefully clean and degrease surface

Table 4 (*continued*)

Description of faults	Causes	Method of elimination
Irregular yarn	Dirt accumulated in centrifuge	Clean centrifuge
	Fillet of combing drum is out of order	Repair or replace combing drum
	Rotational speed of combing drum is too low	Clean fillet of combing drum, adjust belt guiding roller acc. to template
	Collecting surface is damaged	Replace centrifuge
	Yarn Drawing-Off Zone	
No intake of yarn in tube	Tube is clogged with fibres or trash	Take out separator and clean tube and funnel hole
	Wrong connection of separator with delivery tube	Install separator properly
Yarn settles in tube	Tube walls are damaged	Replace tube
	Yarn Delivery Mechanism	
Windings on pressure roller	Guide is damaged	Repair or replace guide
Yarn breaks continuously	Wrong installation of pressure roller (misalignment)	Eliminate misalignment
	Pressure roller shaft it not lubricated	Lubricate shaft
	Yarn accumulated on pressure roller shaft	Eliminate yarn
	Pressure roller is insufficiently pressed to delivery roller	Adjust spring pressure
	Building Mechanism	
Yarn breaks continually	Guide is damaged	Repair or replace guide
	Bobbin is wrongly set in respect to guide	Adjust bobbin and guide
	Bobbin rotates with difficulty	Clean bearings or replace them
	Guide is loose	Repair or adjust guide
Yarn is not properly grasped by bobbin tooth	Bobbin or teeth are out of order	Replace bobbin

Table 4 (*continued*)

Description of faults	Causes	Method of elimination
	Start of Spinning Frame	
All threads on one side break in operation	Belt of centrifuges or of combining drums is broken	Replace belt
	Feeding rollers drive is disengaged	Engage drive
High-breakage rate along frame length in direction of off-end drive	Excessive backlash in joints of delivery and feeding rollers	Take off and replace connecting couplings
High-breakage rate on one side	Belt is loose	Tension the belt and check rotational speed
Spinning frame stops spontaneously	Current is switched off Fuse is blown	Replace fuse
	Mass Centrifuge Threading (Piecing-up)	
Cam runs on safety device	Permanent magnet is demagnetized or passes along hercons with a big clearance	Replace magnet or adjust clearance
	Faulty hercons or relay	Replace them
On depression of push button "THREADING", delivery and winding shafts do not rotate, or turn insufficiently	Coupling (worn-out brushes) or relay are out of order	Replace them
	Jamming of braking couplings	Check braking couplings and if necessary replace them
Delivery and winding shafts fail to change over for working speed	Coupling, hercon and relay are out of order	Replace them
Delivery and winding shafts rotate with jerks at automatic threading	Electromagnetic clutch brushes are worn-out	Replace them
	Jamming in threading mechanism	Check and adjust mechanism
	Drop of voltage in rectifier (one of diodes is out of order)	Replace diode

Table 4 (*continued*)

Description of faults	Causes	Method of elimination
After machine stoppage yarn is not drawn out	Hercon is installed wrongly Batteries of capacitors are incompletely charged or have partially lost their capacity	Check and set properly hercon Check or partially replace them
On frame stoppage yarn is completely drawn out from centrifuge	Hercon or relay fails to operate	Check and replace them
	Piecing-up Mechanism	
On movement of lever from nonworking to working position the yarn is grasped by guide	Improper adjustment of supporting spring	Proceed to adjustment
Paraffiner does not rotate	Holder is contaminated	Clean holder
Yarn fails to be threaded	Centrifuge funnel is clogged with paraffine	Clean funnel
	Yarn Drawing-off Arrangement	
Yarn breaks in winding	Guide is damaged	Replace it
Jamming of sucked yarn	Sucking hole of yarn drawing-off arrangement is damaged Bobbin is damaged Insufficient suction	Proceed to its grinding Replace bobbin Tighten fan driving belt
Improper tension of sucked yarn	Low rotational speed of fan Pneumatic cabinet is full	Ditto Empty pneumatic cabinet
Yarn breakage in bunch formation	Knives of shearing device are improperly pressed	Using a spring adjust proper pressure on knives

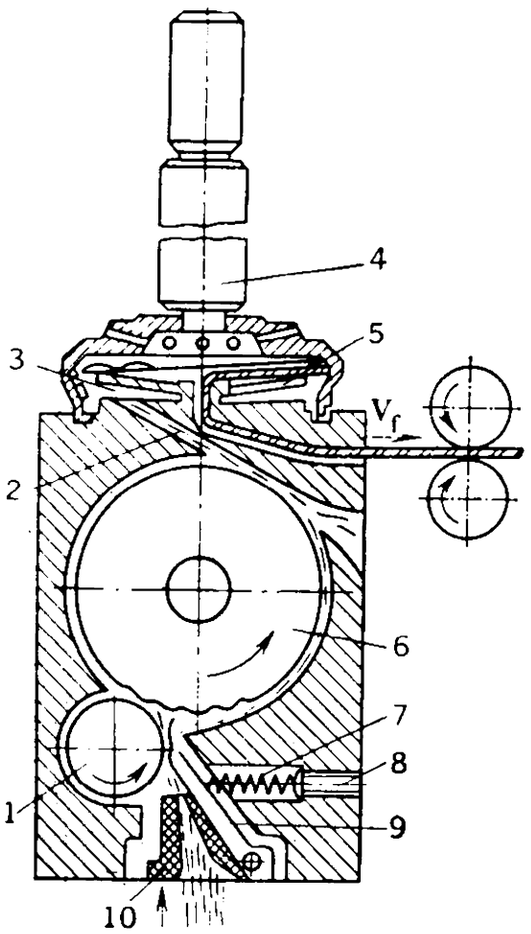


Fig. 97. Diagram of spinning head in open-end spinning frame

spinning head consists of the feeding cylinder *1* (Fig. 97), the funnel *10*, the feeding table *9*, the adjustment screw *8*, the spring *7*, the combing drum *6*, the separator *5*, bearing *4*, rotating centrifuge *3* and transport canal *2*. The main units of the spinning head are: the feeding unit, the combing drum and the twisting and building unit.

The feeding unit consists of the feeding roller *1* and the table *9*. The main kinds of disarrangements are: breakage of the table and funnel wear of the worm gear actuating the feeding roller. Because the feeding unit cannot be disassembled, it must be completely replaced when its parts come out of order.

The state of the *combing drum 6* is determined by the condition of its closing. Its main disarrangements are broken teeth and deterioration of the whole-metal saw-toothed fillet. In this case the combing drum is replaced by a new one.

The twisting and building unit consists of the centrifuge *3* rotating on a shaft, the bearing *4* and separator *5*. The main disarrangements are: contamination, oil penetration and carbon deposit. In this case, the centrifuge is replaced by a new one. Bearings wear and loose separator fastenings are also a frequent case.

The reliability of the spinning head is highly dependent on the strict adherence to establish dimensions in assembly and operation of its units. For this the control and measuring devices shown in Fig. 98*a-c* find application in maintaining the preset dimensions $7^{+0.3}$ and $2.6^{+0.5}_{-0.3}$ mm, as well as a clearance of 0.3 mm.

In installing the feeding table it is necessary to maintain the dimension *A* within the minimum and maximum clearances between the table and the feeding cylinder as well as the established pressing effort of the roller to the cylinder. The dimension *A* is adjusted by means of a special device depending on the kind and length of the processed fibre: for cotton fibre it is equal to 69.2 $\pm$ 0.1 mm and for main-made fibre—68.5 $\pm$ 0.1 mm. The spring effort is checked by a dynamometer, the control effort being equal to 24 $\pm$ 1.5 N.

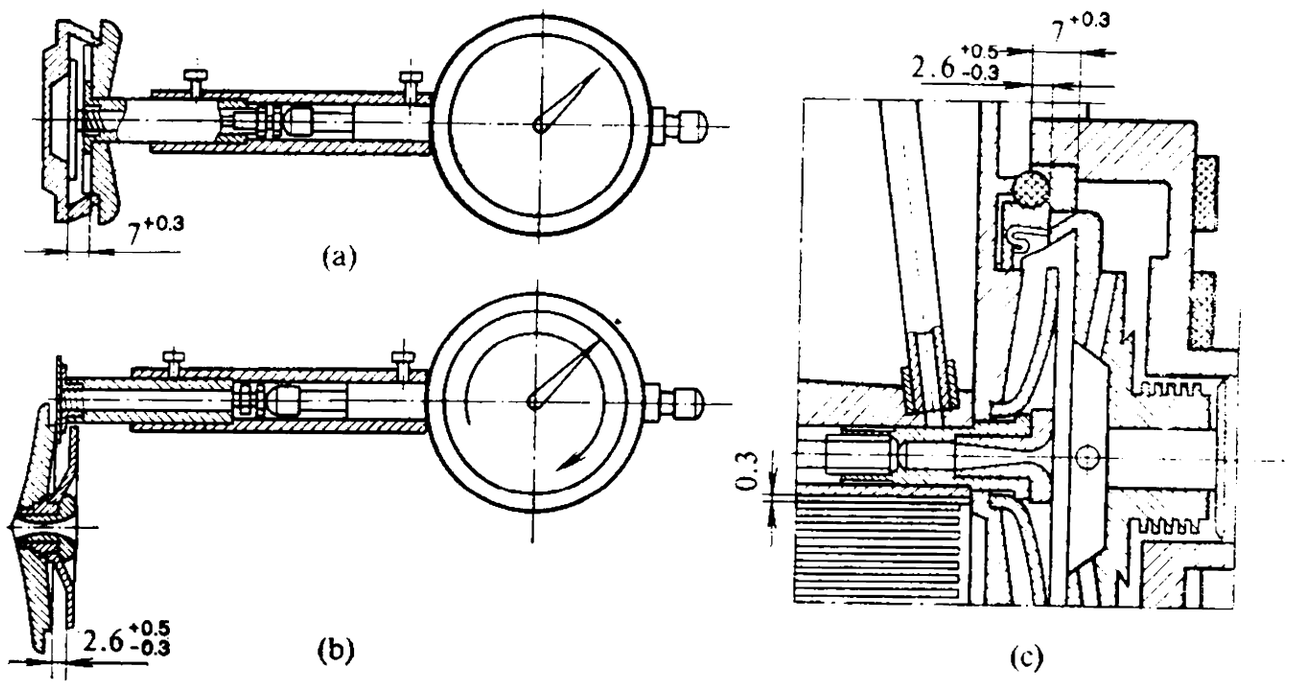


Fig. 98. Devices for controlling mounting dimensions at assembly of centrifuges

When installing the separator, care should be taken that its shaped cut-out is properly positioned in respect to the inlet hole of the transport canal. For controlling the position of the shaped cut-out use is made of a special device. The separator may be set to two positions: for processing cotton fibre at an angle of 15°, and for processing viscose fibre and its blends with cotton at an angle of 45°.

To ensure the easy rotation of the combing drum, there must be a clearance of 0.3 mm between its end face and the applied gauge.

At the assembly of the spinning head in an open-end spinning frame it is necessary to check with a special feeler the clearance of the electromagnetic clutch of the feeding unit, as the proper engagement and disengagement of the feeding cylinder depend on this clearance. It is also important to check the proper installation of the yarn breakage sensor (in particular, using a special gauge it is ascertained that the carrier does not impede the passage of the yarn into the centrifuge at mass threading).

It is observed that in open-end spinning frames БД-200-М69 the yarn sometimes winds on the drawing-off roller causing its scoring. This results in a higher breakage rate and lower yarn quality. For grinding the drawing-off roller the spinning frame should be stopped and the roller taken off.

To increase the machine efficiency it is recommended to grind the drawing-off rollers in the cause of machine operation. For this, at the point of scoring the pressure roller with elastic cot is removed and in its place a wooden block is put; the block has two working surfaces coated with emery paper of different grain sizes. The block

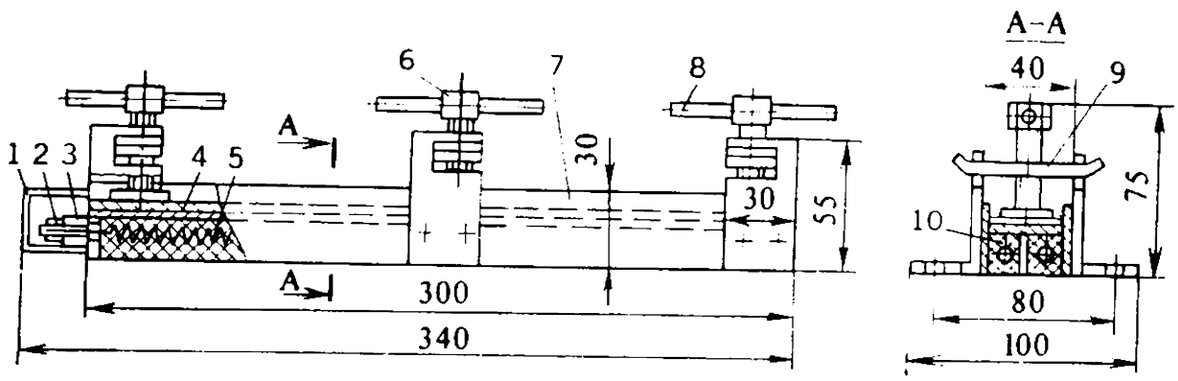


Fig. 99. Vulcanizer for belt glueing

is pressed to the drawing-off roller by a spring. Grinding is first done with a coarse emery paper and then with fine emery paper for which the block is turned about 180°.

Vulcanizer for belt glueing. It has proved efficacious to glue the belts of open-end spinning frame БД-200-М69 which have come out of order. For this, a special vulcanizer is used consisting of the housing *1* (Fig. 99), the shell *7*, terminal *2*, insulator *3*, cover plate *4*, heating element *5* (for 24 V), jimmy bar *8*, clip *9* and thrust bearing *10*. Prior to glueing the belt is machined to conical shape over a length of 40 mm. Next, it is coated with glue, inserted in the vulcanizer, pressed with bolts *6* and after switching-on the current kept at least two hours at a temperature of 110-120°C. The glue employed for belt glueing consists of hydraulic alcohol, resercine and formic acid ethyl ether.

Note another device available for glueing simultaneously two belts. The device consists of a square 250 × 250 mm sides and 60 mm long made of textile-based laminate; one heating and one ironing element with a thermoregulator are mounted in the hollow middle of the square. On the working part of the iron four flanges are attached forming two grooves in belt width; at the top on stands, secured in the body of the textile-based laminate a steel strap is attached having two holes with a thread M14. Spring bolts with washers for pressing the belt through the cover plate are screwed into the hole of the strap.

Device for lubricating the bearings in the centrifuges of the spinning frames БД-200. The main cause of disarrangements in the centrifuges of the spinning frame БД-200 is the insufficient lubrication of bearings. A device has been designed for replacing the lubricant under pressure without dismantling the centrifuges.

The device consists of a cylindrical chamber *5* (Fig. 100) housing in its interior part *9* the centrifuge *12*, and of a shell *10* having its butt face packed with a gasket *8*. The shell *10* is arranged on the annular protrusion before the pulley *17*. On the butt face of the pulley there is provided the gasket *6*. The interior part of the chamber

is of the same configuration as the shell *10* and pulley *17* of the centrifuge *12* with gaps for the passage of the lubricant. Fixed to the chamber *5* is the pressure lever *13* with spring *15* and fixing arrangement *14* ensuring a tight adherence of the butt faces of the shell *10* and pulley *17* to the gaskets *8* and *6* and their fixing in preset position. The injector *19* with a crank *18* and hose *4* is connected to the branch pipe *7* provided in the interior part of the chamber in which the pulley *17* is arranged between the packing gaskets *8* and *6*. The chamber *5* is designed so that on installing the centrifuge *12* inside it, the top butt face *16* of its shell *10* and the spindle *11* protrude from the chamber long enough to allow the visual control over the discharge of the lubricant excess from the chamber. The injector *19* is mounted on the base *1* to which the chamber *5* is attached by means of the bracket *2* and nut *3*. The crank *20* of the injector *19* serves for periodically pumping the grease which is fed by means of the crank *18* into the cavity of the shell *10*.

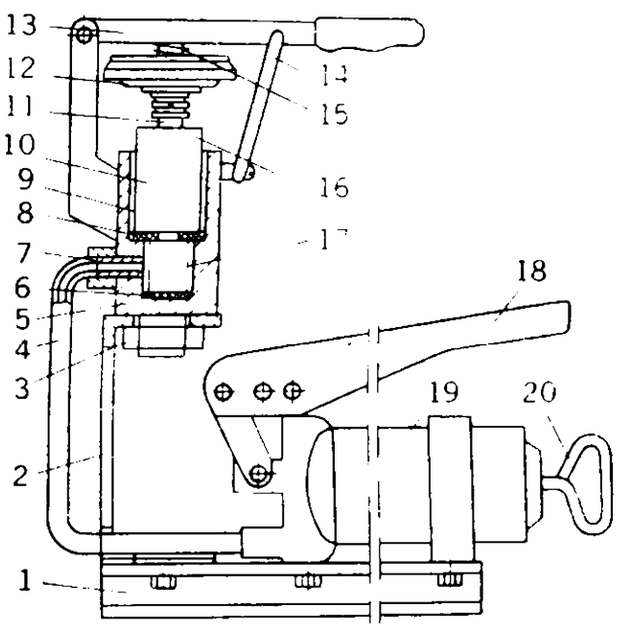


Fig. 100. Device for lubricating bearings of centrifuges in БД-200 spinning frames

The device operates as follows: the centrifuge *12* is placed into the interior part *9* of the chamber *5* so as to obtain that the shell *10* bears with its butt face against the gasket *8* and the pulley *17* bears against the gasket *6*. Using the lever *13*, the centrifuge *12* is pressed by means of the spring *15* and fixed in place by the locator *14*. The butt faces of the shell and pulley must be tightly pressed to the gaskets to avoid the leakage of lubricant through the clearances bypassing the cavity of the shell *10*. Using the crank *20*, the grease is pumped by the injector *19* through the holes *4* and pipe union *7* into the cavity of the chamber *5*, i.e. into the zone of the pulley *17* between the gaskets *8* and *6*. As a result the grease passes under pressure through the clearances into the cavity of the shell *10*, and displacing the old grease lubricates the bearings. The amount of lubricant is controlled at the spindle *11* on the upper butt face *16* of the shell *10*. When the bearings are amply greased, the lubricant oozes out from the cavity of the shell *10* in the zone of the spindle *11*.

Assembly and Adjustment of Spinning Frames

At the assembly and adjustment of *ring spinning frames* a special attention should be paid to the rectilinearity of the stand by checking it with a calibrated roller along a string tightly drawn between the exterior ribs of spindle rails. The difference in the distances between the exterior ribs and the string should not exceed 0.5 mm. The horizontality of the top surfaces of roller beams is checked in longitudinal and crosswise directions by means of a three-metre ruler, a level, and a feeler (the deviation should not exceed 0.15 mm). The ring plates should be mounted strictly horizontal. The total stroke of the condenser should be 18-19 mm.

The deviation of the drafting fields in apron drawing units should not exceed 0.25 mm; the bottom apron plate should be by 0.2-0.5 mm higher than the level of the working fluted parts of the rollers in the first and third lines; the roller flutes must be smooth without indentations and burrs; separate staffs of rollers should be without longitudinal shift. It is necessary to check the proper adherence of rollers to the stand. Lamellar yarn separators and antiballooning rings must be smooth and without burrs. The deviation of the spindle driving tape in length should not exceed 3 mm.

The web condensers should be free of such surface defects as burrs and indentations. The clearance between the roller and the tube of the broken-end collector should not exceed 3 mm. The tin drums, lines of fluted rollers, tension rollers, gearing in the frame headstock should be easily rotated by hand. The poker bushings are installed strictly vertical, and the yarn separators—in the middle between spindles. Side shifting of the yarn guide along the spindle axis is not allowed; the yarn guides are set strictly according to a plumb bob. The fluff catchers are mounted according to a gauge at a distance of 1 mm from the traveller.

At the assembly and adjustment of *spinning-and-twisting frames* (of the type ПК-100 with a spindle gauge of 100 mm and ПК-100М), the first drum is mounted according to a gauge so that the distance from the drum butt faces to the flats of the off-end frame is 245 mm; the intermediate shafts of the drums must be mounted also using a gauge at a distance of 202.5 and 167.5 mm from the spindle rail. A distance of 30 mm should be maintained between the butt faces of adjacent drums. The misalignment of the drum head shaft must not exceed 0.05 mm. The stroke of the delivery roller carrier should be equal to 10-13 mm. The load applied on the top roller of the drawing unit should be 80-90 N in the first line, 50-60 N in the second and 40-50 N in the third line. The total shift of the bobbin holder lever along its axis due to the gaps in the joints should not exceed 1.5 mm. The left side of the bobbin holder lever and of the building unit lever must coincide in one plane (the deviation should not exceed 1 mm).

At the assembly and adjustment of *open-end spinning frames* the following should be taken into consideration: during the adjustment of the brakes, the clearance between the magnetic solid and the interior part of the adjusting nut should not exceed 0.3 mm; the centrifuge and separator must be strictly coaxial; the play of output shafts in the gear box should not exceed 1 mm; it is not allowed to open simultaneously more than five centrifuges in one section.

REVIEW QUESTIONS

1. Name the units comprised in the blowing range.
2. What operations are carried out at the repairs of the blending feeder and single-process scutcher?
3. How is a cage repaired?
4. Describe the main processes at the repair of rollers and beaters.
5. What are the peculiarities of the pedal regulator repair?
6. What kind of work is done at the repair of cards?
7. For what kind of work the boring bar may be used?
8. With what aim and how is static and dynamic balancing of cylinders carried out?
9. How are the cylinders and rollers covered with fillet? What kinds of fillets do you know?
10. How is the repair of flats, chains and bows of cards carried out?
11. Discuss the peculiar features of the repairs conducted on drawing and sliver-lap machines.
12. How is the repair of fluted rollers and spindles in roving frames carried out?
13. Discuss the repair of roving frame flyers.
14. What are the main procedures at the repair of combers? Name the devices and tools used for the repair.
15. Discuss the repair of drawing units in ring spinning frames and its peculiar features.
16. How is the repair of top rollers carried out and what devices are used for the repair?
17. How is the repair of spindles in ring spinning frames carried out?
18. How are the drums of ring spinning frames repaired?
19. Name the main kinds of disarrangements in open-end spinning frames and the methods of their elimination.
20. Discuss the work of a fitter's shop for repairing the centrifuges of the spinning frames БД-200.

CHAPTER 6

REPAIR AND ADJUSTMENT OF WEAVING MACHINERY

1. Warping Machines

Warping of yarn and threads is carried out in warpers which depending on the method employed for warping are subdivided into beam, section and section-beam warpers (the latter are rarely used).

Preventive scheduled repairs of textile equipment, including those of warping machines, comprise current medium and overhaul repairs. Carried out correctly and in due time current and medium repairs increase the warping machines life.

Current repairs are carried out by shop personnel and consist in the preventive inspection of the equipment by the foreman, assistant foreman and fitter of the shop, for locating and eliminating faults which can provoke the breakage of separate parts and of the machine, as a whole. Such disarrangements are as follows: loose driving belts and pulleys; breakage or loss of protecting guards; loose bolts, keys, and wedge joints; breakage and overheating of bearings; misalignment of brakes and automatic machine stops; breakage of auxiliary parts—braking, yarn guides, etc.; misalignments, indentations and scores on the reed dents, and on the measuring roller and warper's beams; cracks and deformation of parts.

The adjustment of starting, stopping and braking mechanisms, on which depends the quality of warping is also carried out at current repairs. The current repair of warping machines is carried out according to schedule. The results of inspection and current repairs carried out on any of the machines are registered by the assistant foreman in the log book.

Medium repairs are effected by a team of repair workers at least every six months when working in two shifts, and at least every four months when working in three shifts. For the time of medium repairs, the warper is stopped and excluded from the production plan. The following jobs are carried out during medium repairs: checking all machine mechanisms; repair of separate units and replacement of worn-out parts; cleaning and checking of ball bearings; turning the shafts, conditioning of drums and cylinders with elimination of indentations and burrs; replacement of

braking belts, cables and chains; checking of repair and chain drives; checking the setting and adjustment of mechanisms by means of gauges; disassembly, checking and adjustment of starting and stopping mechanisms, and replacement of worn-out parts; adjustment of stopping mechanisms; repair and replacement of auxiliary machine mechanisms, etc.

Overhaul repair of warpers is carried out every two years by a team of repair workers and includes: the replacement of all worn-out parts and units or their restoration, bringing them to dimensions established by specifications; careful examination, centring and balancing of the units and parts of the machine; checking the machine frames and creels.

Beam Warpers

Beam warpers are intended for high-speed warping of yarn from bobbins onto warper's beams. As the warper operates, each yarn coming from the corresponding bobbin passes through the yarn guide eyelet, the yarn tension, and yarn guides which support and separate it from adjacent yarns. Further it is guided into the hook of the warper self-stop which comes in action in the event of yarn breakage (signal frame). The hook retains the yarn in raised position and, in case of its breakage, moves down and closes the circuit causing machine stoppage. Yarns pass in a certain order behind the warping reed between the glass guiding rods through an expanding zigzag-shaped reed, run round the measuring roller and come on the warper's beam which is rotated from a d.c. motor through a clutch, a two speed box and a V-belt drive. As the diameter of the warper's beam increases, the condensing roll is displaced and, through the intermediate of the slider connected with it, changes the rotational speed of the warper's beam, thus ensuring the maintenance of the preset warping linear speed. The machine is provided with independent braking systems for the warper's beam, the condensing roll and measuring roller owing to which it may be quickly stopped in case of yarn breakage.

A modern beam warper consists of the following units and mechanisms: the stand, the drive, the starting and stopping mechanism, the condensing roll, the warper's beam changing mechanism, the reed, the measuring roller, the warper's beam, the manual stop mechanism and the electrical equipment with a unified electric drive system.

The framework consists of cast side frames and several braces. The side frames are provided with reinforcement ribs along the perimeter and surface which considerably reduces their vibration and are tied together by braces, i.e. in the bottom part of the framework there are five braces (three round and two channel braces). Owing to this reinforcement of the frames all the parts of the frame-

work present high stability and ensure reliable fixing of mechanisms mounted on it. At adequate points flats are provided on the machine frames to ensure the accurate installation of shaft bearings and brackets.

The drive transmits the motion from the motor to all mechanisms engaged in the warping process. It must maintain the preset rotational speed of working organs during machine operation. A simple and reliable circuit is employed in the unified drive for automatically maintaining the preset linear speed of warping independently from the change in the winding diameter on the warper's beam.

The starting and stopping mechanism is intended for starting the warper and stopping it in case of interruptions in the warping process or for other causes. This mechanism must ensure the rapid engagement and disengagement of motors and warping organs of the warper. It consists of the following independent mechanisms: for the engagement and disengagement of the drive; for braking the warping organs; and a self-stop coming in action on yarn breakage, and when a warp of preset length has been produced.

The condensing roll serves for compacting the winding on the warper's beam. It consists of the left half *1* (Fig. 101) and right half *4* of the cylinder connected together by the steel ring *3* (new models of warpers are equipped with whole-metal condensing rolls of stainless steel). Inside the cylinder at its ends there are bolted cast-iron rims *7* which serve for braking the condensing roll. The ball bearings *6* are attached on the disks *5* secured to the rims; these bearings are fixed in conical bushings on the shaft *2* around which the condenser roller is rotating. During warping the condenser roller is constantly displaced deep into the machine (progressively with the increase of winding diameter of the warper's beam).

Warper's beam change mechanism. Intended for rapid and easy replacement of the full warper's beams.

The warper's beam consists of the stem *1* (Fig. 102) made of steel pipe 240 mm in diameter. At the stem ends there are screwed or threaded 800 mm dia. flanges *2* cast of light alloys. Couplings *3* attached by pins and screws with the stem are inserted in grooves provided inside the pipe at its ends. Locks *4* for joining the warper's beam with tailstock sleeves are screwed to the couplings. The steel axle *5* carrying the ring *6* for reliably fixing the locks on the axle is inserted into the locks and the ring itself is pinned on the axle. The flanges are cast as a whole with the pulleys *7* serving for braking the warper's beams on the sizing machine. The flanges are provided with reinforcement ribs. The run-out of a 240-mm diameter stem must not exceed 0.5 mm and the end play of flanges 800 mm in diameter must not exceed 1 mm.

It is necessary to systematically check the working condition of warper's and weaver's beams. Checking of the end play of flanges on

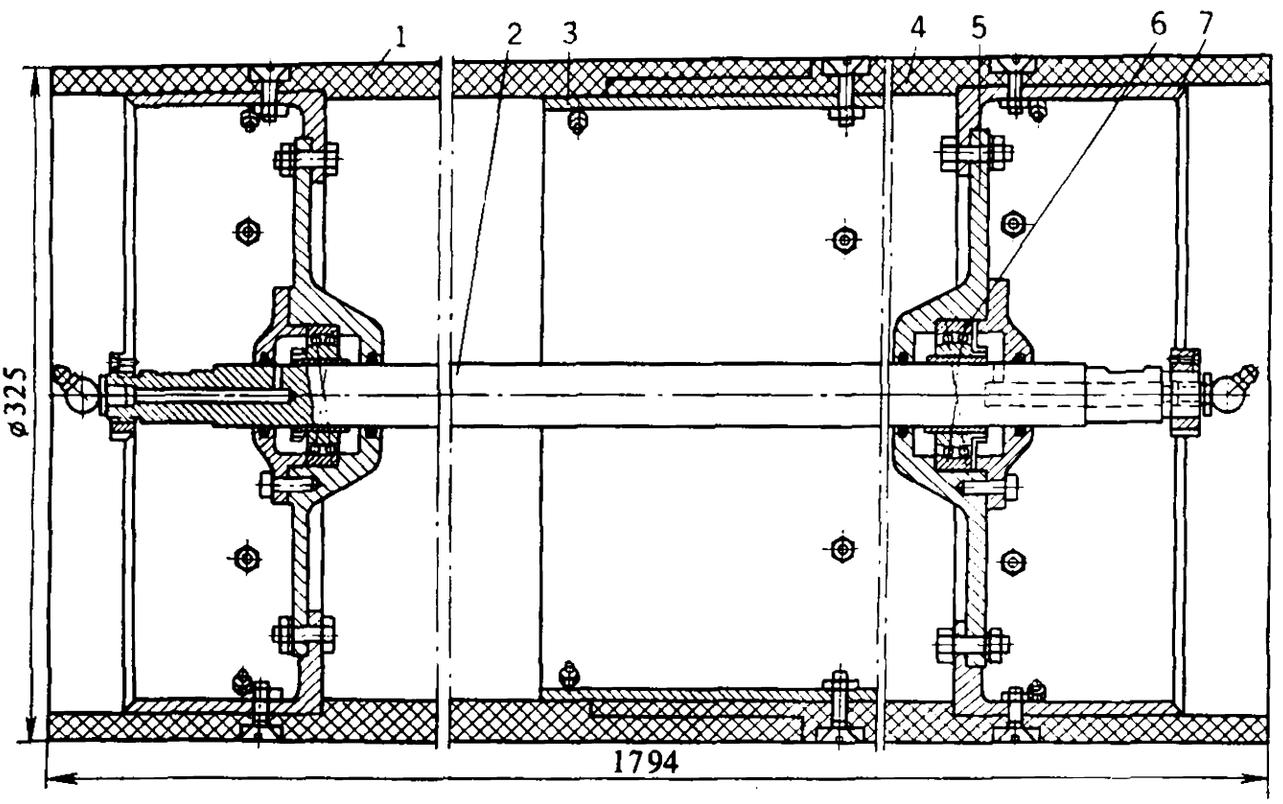


Fig. 101. Warper condensing roll

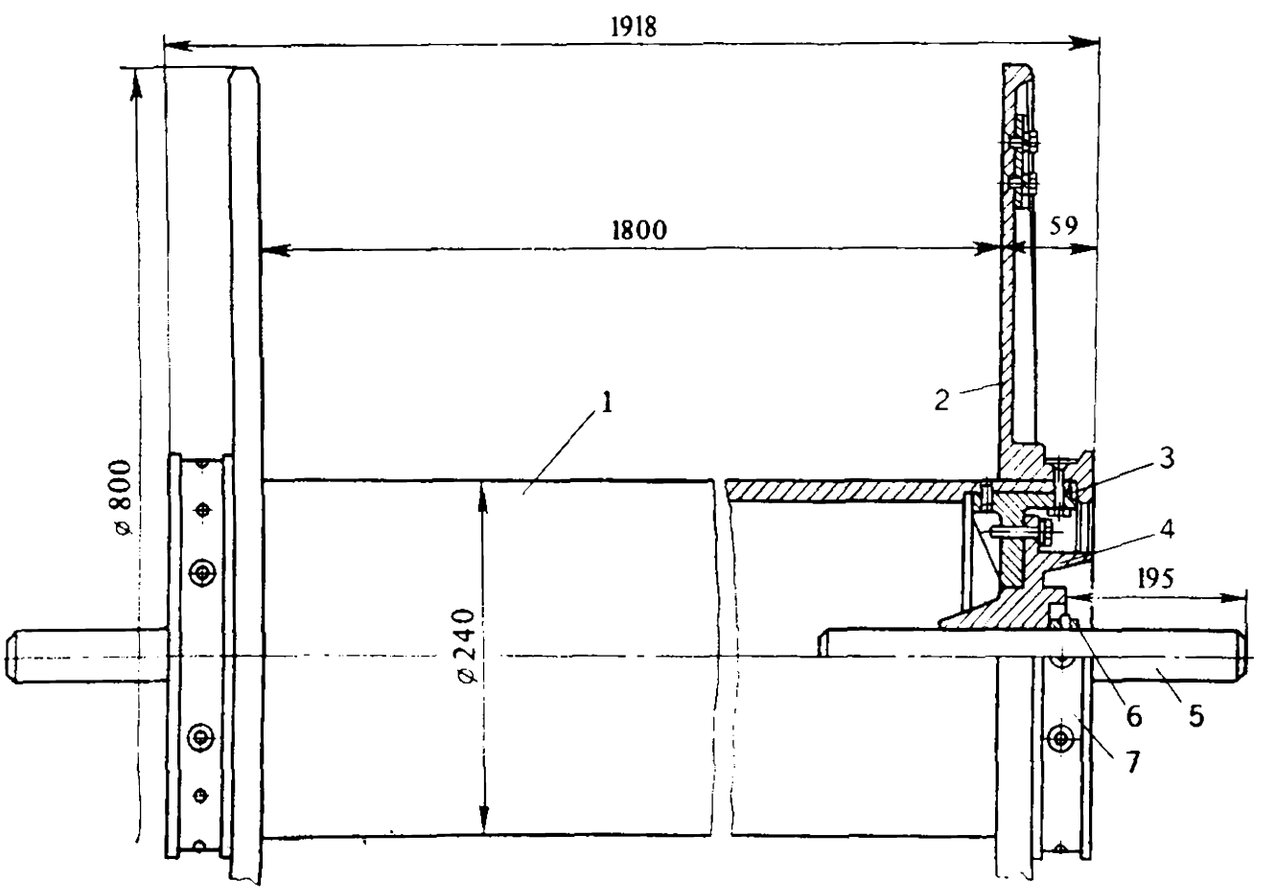


Fig. 102. Warping beam

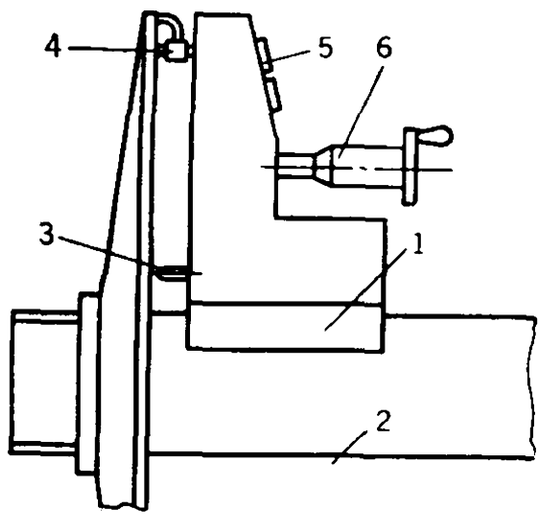


Fig. 103. Device for checking end play of warping beam or weaver's beam flanges

warper's or weaver's beams is carried out by means of a device with a measurement range from 0 to 15 mm. The readings are obtained with a precision of 0.01 mm. This device is placed with its base *1* (Fig. 103) on the barrel of the weaver's beam *2* so as to have a small clearance (1-2 mm) between the pins *3* and *4* and flange surface. Next, tightly holding the device in place (to avoid its shift in respect to the weaver's beam barrel), the crank of the meter *6* is turned until one of the lamps of the signalling arrangement *5* lights up indicating that one of the pins *3* and *4* comes in contact with the flange surface. Then, the first reading is taken on the scale of the meter *6*. After this, the crank of the meter *6* is rotated again until another lamp of the signal arrangement *5* starts burning and a second reading is obtained on the meter scale. The absolute difference between the first and second readings is the run-out of the weaver's beam

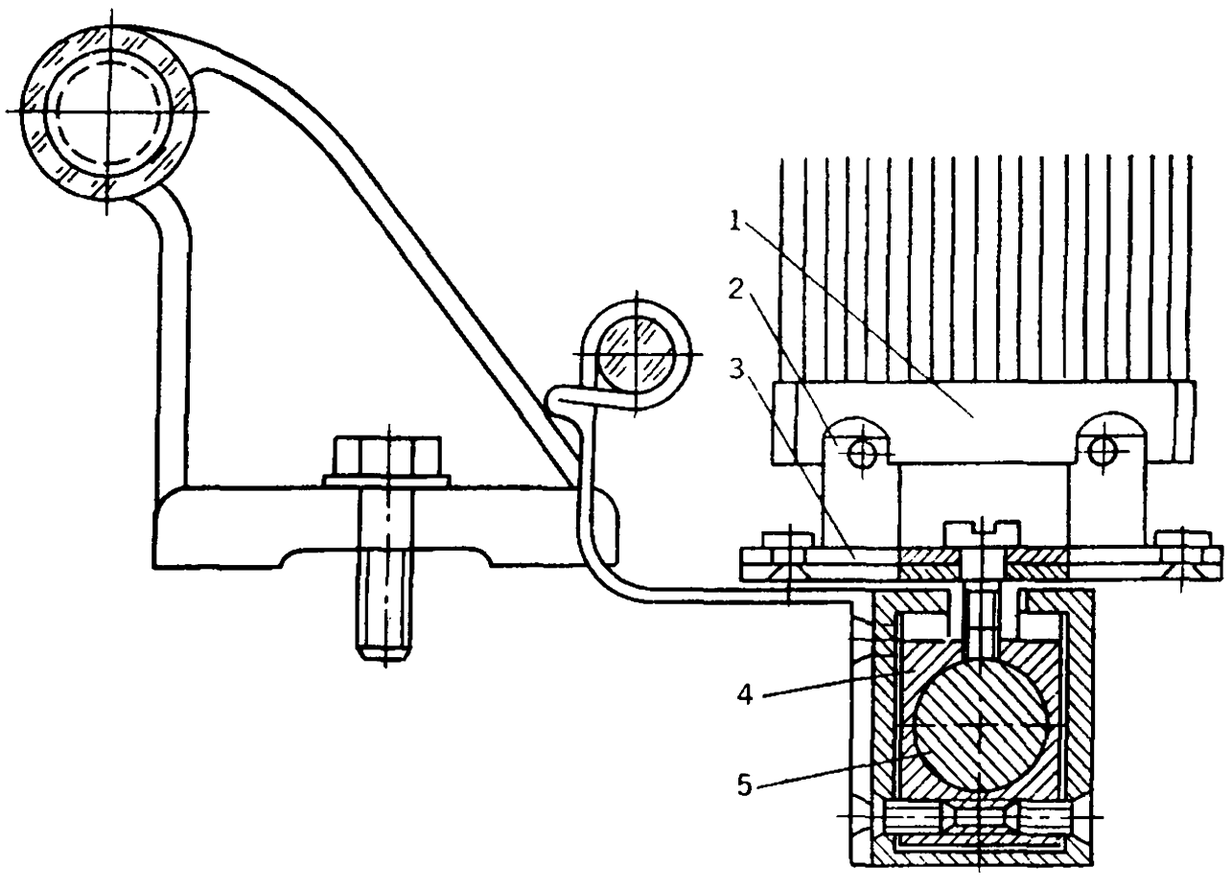


Fig. 104. Section warper reed

flange (or warper's beam) in the given plane of measurement. Measurements are made at least in four different points of the flange circumference.

The reed serves for guiding and regularly spreading the yarns on the warper's beam and also for ensuring the preset warping width and the density of yarn winding on the warper's beam. A special mechanism imparts reciprocal motion to the reed along the axis with a maximum stroke of 8-10 mm which ensures a regular winding of the yarn on the warper's beam. (The reeds of latest designs are displaced in two mutually perpendicular planes.) The reed consists of the combs *1* (Fig. 104) inserted into the stand *2* of the staffs *3* articulated together and forming a zigzag line. This line is screwed on the nuts *4* fitted on a screw roller *5* mounted on the beam. On the right- and left-hand ends of the screw roller hand wheels are provided: the first one is used for adjusting the width and density of warping and the other for adjusting the position of the reed in respect to the warper's beam.

The mechanism for braking the warper's beam and the condensing roll and measuring roller is constituted of powerful double-shoe brakes disposed at both ends of the beam and rollers. During the time the warper is in operation the whole braking mechanism is disengaged and the brakes are engaged at machine stoppage. Braking and unbraking of the warper's beam, the condensing roll and the measuring roller occur simultaneously. The disarrangements most often encountered at warping in beam warpers are listed in Table 5.

Section Warpers

Section warping machines are intended for warping the yarns in sections on the drum with subsequent beaming them on the weaver's beam. Each section is laid on the drum by means of a reed provided on the warping table, which at each drum revolution is displaced over a nominal distance. A certain number of sections form a warp which is wound onto the weaver's beam. As sections are produced, the machine shifts so as to ensure centring of the warping table in respect to the creel. There are two types of section warping machines: type I—machines for warping woolen and cotton yarn; type II—machines for warping yarns of natural and synthetic fibres as well as glass fibres.

The section warping machines consist of the following main mechanisms: the framework, the drive, the drum, the warping table; the drum starting mechanism, the counter, the feeding mechanism, the beaming mechanism, and the warp length counter.

The framework is assembled of channels. It carries the frames, braces and all the machine mechanisms.

The drive (a common drive for the drum and the weaver's beam)

Table 5. Main Defects Observed at Warping in Beam Warpers

Description of defects	Causes	Methods of elimination
Soft winding of yarn on warper's beam	Insufficient pressure of warper's beam to drum or condensing roll to warper's beam	Check gearing and parallelism of guiding rails, as well as position of chain on sprockets and weight on chain
In unwinding warper's beam on sizing machine, yarns at beam edges get slack	Reed combs are improperly set at that edge. Yarns are laid in groups so that winding diameter is increased as compared with other parts of winding	Set combs at the same angle to reed axis and so as to have same distance between teeth
	Entire reed is mounted wrongly. Edge yarns have accumulated at beam flange and winding has a greater diameter than in other points	Set reed so that warp edge yarns do not contact flanges and are at the same distance
	There is a run-out of warper's beam flanges due to which in some parts of its circumference warp is compressed at flanges, thus forming a bulge, and in other parts warp is loose and forms recesses	Set right flange. Beams with incorrectly mounted flanges are not allowed to be mounted on warper
Different tension of yarns. Some yarns get loose in unwinding of warper's beam on sizing machine	Some yarns are not braked due to their improper threading into brakes, due to improper operation of brake caused by irregularities of its surface under washers, or due to absence of a weighting washer	Check yarn threading in brakes and eliminate defects. Examine working surfaces of brakes and replace brakes with irregularities on working surfaces. Put in place required number of weighting washers

Table 5 (*continued*)

Description of defects	Causes	Methods of elimination
Breakages of edge yarns on warper's beam in sizing	Burrs or indentations on the inside surfaces of warper's beam flanges	Eliminate burrs and indentations on flanges on warper's beam
Insufficient or excessive length of yarns on warper's beam	Disarrangements in counter and its improper operation. Counter has been incorrectly set at beginning of warping	Adjust counter and check its operation. Check proper setting of counter at beginning of warping
Broken ends on beam	Simultaneous breakage of several yarns and their improper tying-in by warper, i.e. instead of tying-in each yarn separately, operator ties them in bundle or laps them over on beam	Find ends of all broken yarns on warper and proceed to proper tying-in
Bulges on warper's beam	Operator fails to find broken yarn end, and does not tie it with end coming from bobbin, but simply laps it over	No yarn overlapping is admissible. If on breakage, yarn end winds up on beam, it is necessary to stop machine and to repair self-stop and braking system; end of yarn which has not been found must be tied to adjacent yarn
Pinches. Separate yarns coming from warper's beam cross with adjacent yarns and are difficult to draw out from under them	Braking system is out of order. Operator fails to find end of broken yarn on beam, breaks adjacent coil and ties to it yarn end from bobbin	Located yarn end is to be brought between adjacent yarns and tied in this position. Breaking system must be adjusted. No pinching and breakage of adjacent coils is allowed. Find wound end of yarn or tie broken end of yarn to adjacent one

consists of an electric motor, a speed variator, a reducer with electromagnetic couplings and a speed regulator. The drum and weaver's beam are imparted rotation from the electric motor through V-belts, the speed variator, a chain drive, the reducer with electromagnetic couplings and a V-belt drive for the drum, and friction coupling for the weaver's beam. A mechanical friction clutch is additionally provided on the weaver's beam drive. The speed of warping and beaming is maintained automatically. A stepless procedure is employed to regulate the speed.

The drum of the first type warping machine is a whole-metal cylindrical part with a cone the angle of which changes from 6 to 26°. The cylinder is made of aluminium sheet, and the variable cone consists of 24 telescopic wedges. The cone angle is modified by means of a leverage system and a movable coupling.

The drum of the second type warping machine is a whole-metal cylinder with a constant cone. The cylinder and cone are made of aluminium sheets and from both sides the drum is provided with belt brakes ensuring the rapid stoppage of the machine and normal braking of the drum in warp beaming. The brake is equipped with an automatic regulator to maintain a constant warp tension in beaming. The braking force is adjusted by the brake regulator.

The warping table consists of a carriage with a reed, a measuring ruler, a friction clutch and a bracket for mounting the static eliminator. Mounted on the warping table is the lease reed and the shedding motion for laying the lease. The warping table together with the carriage rests on the guide and travels in ball bearings along it. Serving as a second support for the table, the stands connected with the car house the end switches for the automatic engagement of the machine displacement motor. The machine is periodically displaced with a speed of 2.03 m/min. The deviation of the warping table from the creel centre is equal to 70 mm, i.e. to the distance between the end switches.

The drum starting mechanism effects the engagement and stoppage of the machine. The engagement and disengagement are effected from one treadle running along the machine. The mechanism has treadle levers loosely fitted on the shaft. Through pawls they are connected with the unbraking levers and are fixed in working position by a locator connected with the electromagnet and disengagement pawl.

The counter mechanism ensures machine stoppage after a preset number of revolutions and when a complete section is finished. A tachometer is provided to determine the warping speed. The warp length counter and tachometer are actuated from the drum through a chain drive, a friction speed variator and a reducer; and the counter of revolutions—from the drum through a chain drive, a reducer and a worm couple.

Table 6. Main Kinds of Disarrangements in Section Warpers

Description of faults	Causes	Methods of elimination
Handle of warping table friction clutch is shifted down, but table does not move	Wedging of conical half-coupling rod and spring breakage	Check rod for easy displacement and spring for good condition
A stock fails to travel on lead screw	Key of worm gear (in meshing with screw) is sheared	Replace the key
	Gear meshing with microscrew is not engaged	Check the engagement and fix in proper position
Current is not supplied to cabinet with electric equipment	Automatic disengagement switch fails to operate	Check and eliminate the fault
Electric motor fails to operate	Magnetic starter contacts are burnt	Clean the contacts
	End switch is off	Adjust the pedal on-system
	End switches are disengaged	Shift away the fork from the end switch
Electrodes are out of order	Electromagnetic clutch is not under voltage	Check the safety fuse or diodes
	Brushes have no contact with ring	Check the brushes
As machine is started, stopping electromagnet comes in action	Counter contacts are closed	Set the counters in zero position
	End switches are disconnected	Shift away the fork by means of hand wheel
	Signal frame contact is closed	Eliminate contact closure (breakage or sagging of yarn)
Machine does not stop at yarn breakage	Stabilizer diode is out of order. The fuses or electromagnet is burnt	Check and replace faulty elements

During overhauls, the warping machine is completely dismantled with the exception of the framework. After dismantling the parts are washed, wiped and examined for wear. The machine framework is checked with a lever. As they are assembled, the mechanisms are checked for easy rotation by hand and their operation is adjusted.

The main kinds of disarrangements in section warping machines, their causes and methods of elimination are listed in Table 6.

Adjustment and Lubrication of Beam Warpers

Adjustment. The adjustment is carried out without the warper's beam, proceeding in the following order:

1. The treadle *1* (Fig. 105) is depressed with the foot at which the pawl *9* moves behind the tooth of the catch *10*. The clearance between the levers of the treadle *1* and the brace must be 5-8 mm. The clearance is adjusted by changing the length of the rod *12* using the tie with subsequent fixing it with nuts.

When the treadle is released by taking off the foot, it must be raised upwards by the spring *13*.

2. By adjusting the length of the rod *18* a position is obtained in which the braking pulley of the warper's beam may be easily turned

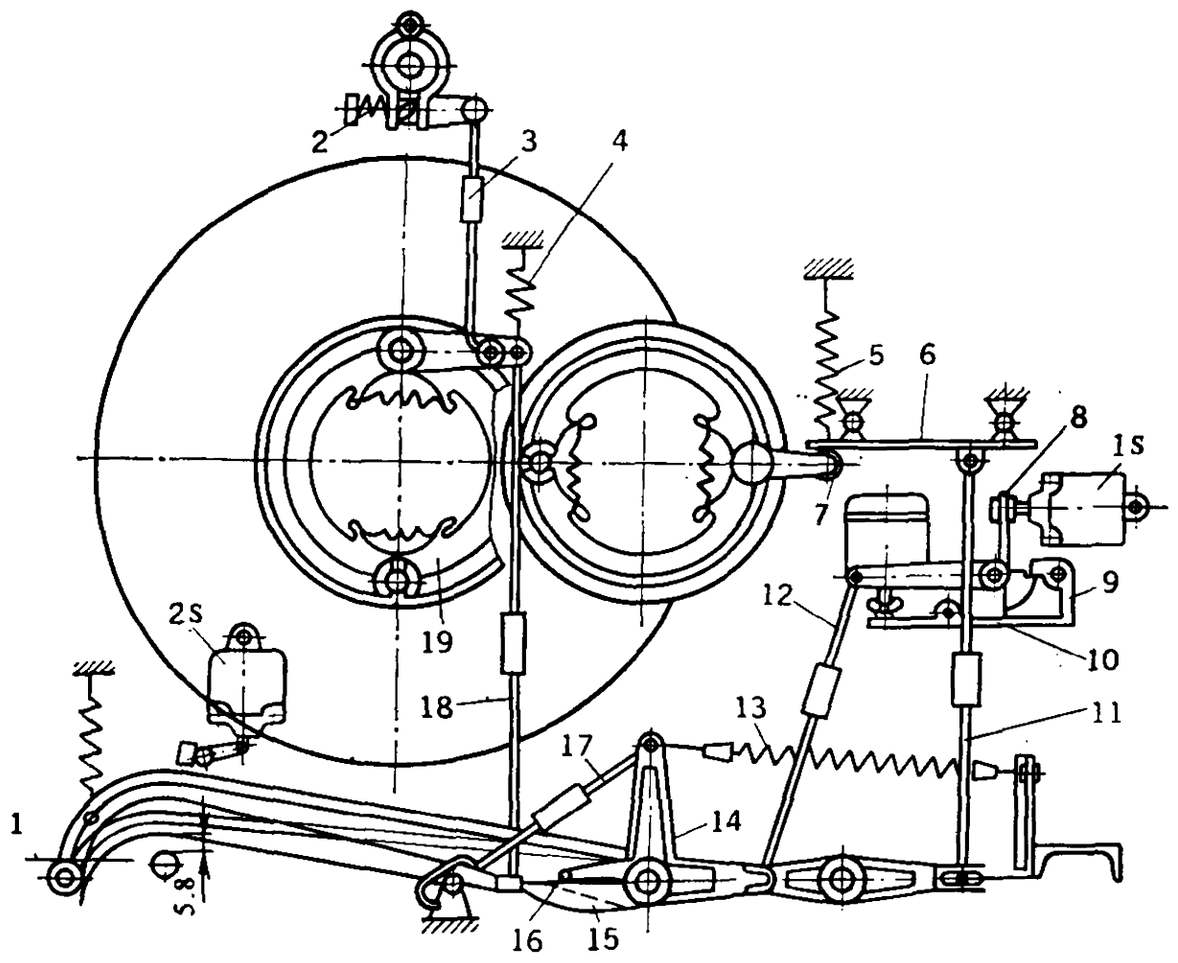


Fig. 105. Diagram of section warper brakes

by hand. The left-hand braking pulley *19* is adjusted in the same manner.

3. By adjusting the length of the bolt *8* a position is obtained in which the normally open contacts close with a 2-3 mm overrun of the rod of the end switch 1BK.

4. On engagement of the machine, the lug on the left lever of the treadle *1* must press against the roller of the end switch 2BK and shift it over an angle ensuring a sharp change-over of the contacts. On return of the treadle upwards the lug must release the roller of the end switch 2BK. The position of the end switch is adjusted by displacing it along the frame together with the bracket.

5. By disengaging the machine which is made by turning the catch *10* and releasing the pawl *9* it is necessary to check: (a) clearance between the head of the bolt *8* and the rod of the end switch 1BK. If there is no clearance it must be obtained by modifying the length of the rod *17*. The clip of the rod *17* must be pressed to the brace under the action of the return spring *13*. If the clip of the rod *17* does not reach the brace, it is necessary to locate the rod which impedes the motion and to release it; (b) clearance of 1.5-2 mm between the levers *15* and *16*. The clearance is adjusted by modifying the length of the rod *18*; (c) clearance between the butt tooth of the bushing of lever *16* and the tooth of the bushing of the lever on the treadle *1*; the clearance from the right and left sides of the machine must be equal to 1.5-2 mm to protect from teeth impact on machine stoppage. The clearance is adjusted by modifying the length of the spring of treadle *1*.

6. On machine engagement the condenser roll and measuring roller are checked for easy rotation. By adjusting the length of the rod *11* it is possible to obtain easy rotation by hand of the condenser roller. A clearance must be maintained between the braking plate *6* and the roller of the condensing roll *7*. When the machine is disengaged the condensing roll must be braked. By adjusting the length of the rods *3* the easy rotation of the measuring roller by hand is achieved and when the machine is in disengaged position the force of its braking is adjusted.

7. The braking of the warper's beam and of the condensing roll and measuring roller is definitely adjusted so as to obtain their simultaneous stoppage; the adjustment is effected by modifying the tension of the springs *2*, *4* and *5* when processing the first warper's beam.

8. The rapid rotation of the lever *14* with the roll on machine stoppage, ensuring a reliable operation of the brakes, is obtained by adjusting the spring *13*.

In gaiting the machine the yarns are passed in each reed dent. The ya ns may also be placed every other tooth, but in that case the reed must necessarily be shifted. The amount of reed shift must

be equal to the yarn laying pitch. In installing the warper's beam, the machine must be engaged in the power line, the warper's beam must be rolled on the lifting levers and the push button "warper's beam" must be depressed. The lifting levers will butt against the rests and the safety clutch will turn. Next, the button "tail spindle" must be depressed and the safety clutch will be brought in operation. In case of improper operation of the safety clutches, they must be adjusted, for which it is necessary to loosen the counter nuts, to tighten the clutch screws as far as they will go and then to turn out the screws over 0.5-1 coil. At the same time, the warper's beam must be checked for proper lifting, lowering and clamping by the tail spindles. The warper's beam should be rotated by its flange so as to obtain that the tail spindle catches engage the beam recesses. The extreme position occupied by the tail spindles when they are set apart, is set by means of an adjusting bolt which butts against a finger when the coupling ratchet comes in action. It is not allowed to rotate the tail spindles by motor without the warper's beam in place.

Lubrication. The lubrication is carried out according to schedule and depending on the condition of the machine (Table 7). The holes for oil lubrication must be clean and without clogging. The excess of

Table 7. Lubrication Schedule of Beam Warper Mechanisms

Mechanism	Lubricant	Number of lubricating points	Method of lubrication	Periodicity of lubrication
Framework	Industrial oil	2	Hand oiler	Once a week
Drive	Industrial oil	6	Hand oiler	Once a week
	Cup grease	12	Grease gun	Grease is added once a month and replaced during preventive repairs
Starting mechanism	Industrial oil	6	Hand oiler	Once a week
	Cup grease	2	Grease gun	Adding grease Once a month
Condenser roll	Industrial oil	2	Hand oiler	Once a week
	Cup grease	2	Grease gun	Adding grease Once a month
Warper's beam changing mechanism	Cup grease	6	Grease gun	Once a month
	Industrial oil	6	Hand oiler	Once a week
Reed	Industrial oil	6	Hand oiler	Once a week
Measuring roller	Cup grease	6	Grease gun	Adding grease Once a week
	Industrial oil	2	Hand oiler	Once a week
Manual stop mechanism	Industrial oil	4	Hand oiler	Once a week

oil must be eliminated and only clean and non-acid oil should be used. The ball bearings should be washed at least once a year. The amount of grease packed in the ball bearings shells should be equal to about 3/4 of their free space. Open gearings should be greased at least once a week; and articulated joints and chains should be lubricated by means of a hand oiler with industrial oil after each machine cleaning, but not fewer than once a week.

Adjustment and Lubrication of Section Warping Machines

Drum brake. The adjustment is started with the drum braked. Using the handwheel *2* (Fig. 106) the spring is tightened so that its length is about 340 mm. Next, by modifying the length of the rod *3* a clearance of 1.5-2 mm is set between the roller *5* and the lever *4*. The drum should be braked at 3/4 of a turn which is achieved by the definite tensioning of the spring (its length may be in this case somewhat greater than 340 mm). When the drum is unbraked, the braking belt must retreat from the surface of the braking pulley. The clearance is adjusted by shifting the fingers *1*.

Drum revolution counter. Prior to machine running-in after the erection, it is necessary to adjust the normal tension of the mechanism driving chain and to check the easy displacement of the slider *7* (Fig. 107) along the thread of the drum *4* and the guiding shaft *6*. For checking, the slider *7* must be retreated, so that the operator must pull the crank *1* until it comes out of the drum helical groove and must manually displace it several times along the shaft *6*. Next, the slider must be set at the beginning of the groove so as to bring its butt face in coincidence with the match mark (the beginning of count). Releasing the drum the worker must rotate it from himself until the slider passes the whole thread (it must be an easy displacement along the drum). Then it is necessary to insert the stopping pins (pegs) according to the preset operational cycle. The distance between the pin holes is equal to one revolution of the warper's drum (3 m). If there is deviation of the slider for laying the leases the indicator "Lease Laying" lights up, and for warp replacement two other lamps "Lease Laying" and "End of Warping" start burning which is achieved by adjusting the screws under the lugs *3* and *2*. Prior to warping the butt face of the slider *7* must be brought in coincidence with the match mark on the drum and the handwheel *5* after which the drum is to be fixed on the shaft. At this time, the section must be attached on the warper's drum. For passing from warping to beaming, the drum must be released and the slider should be shifted away outside the drum limits, as otherwise mechanism breakage might ensue.

The counter of warp length is engaged individually for each new section, proceeding in the following order: (1) the handle *1* (Fig. 108)

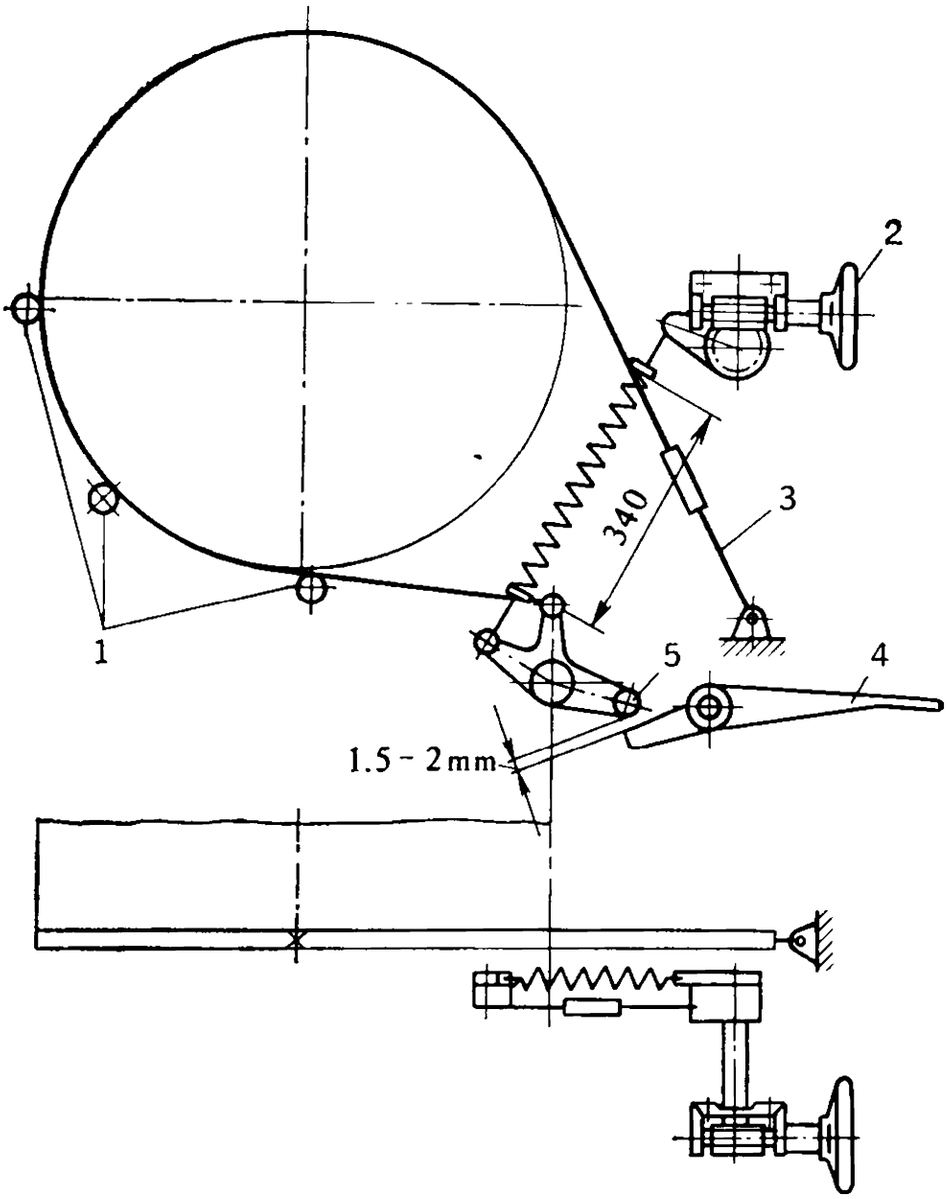


Fig. 106. Diagram of section warper drum brake

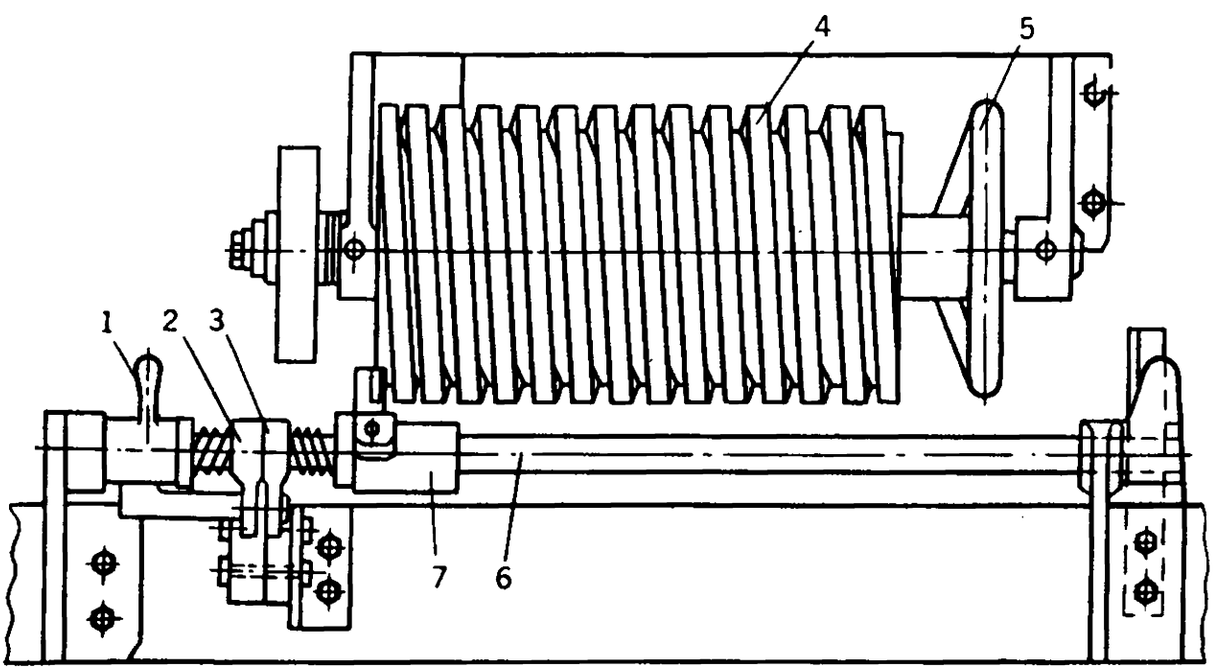


Fig. 107. Counter of revolutions of section warper drum

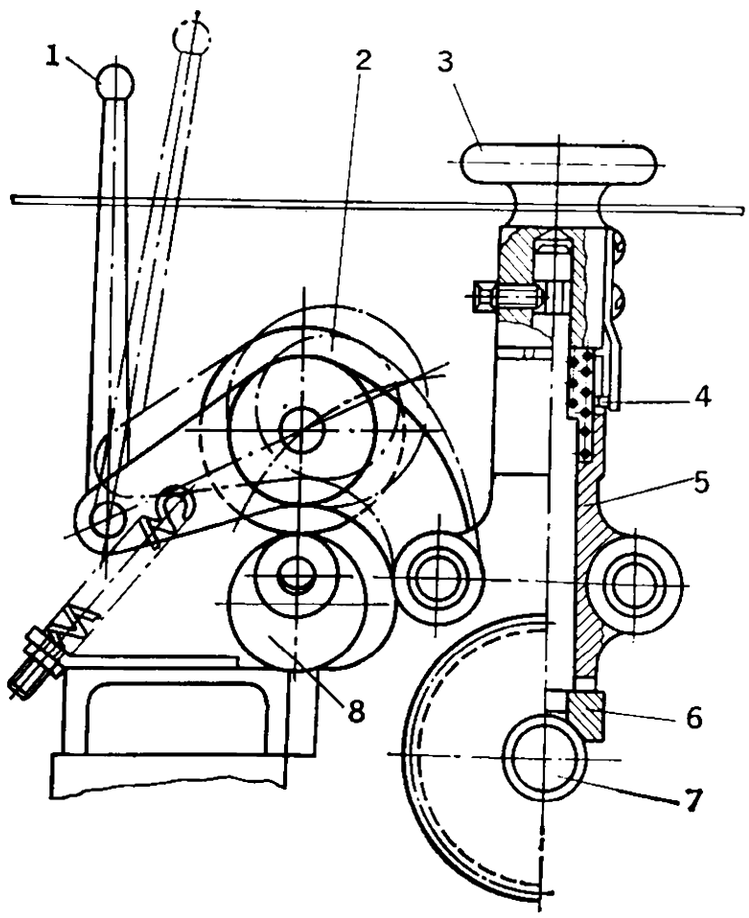


Fig. 108. Counter of section length wound on section warper drums

is set in the fixing slot on the guards at wnich the friction disk *2* must retreat from the cone *8*; (2) turning the handle *3* the finger *4* is engaged in the vertical slot of the carriage *5*, at which the slider *6* must be disengaged with the screw *7*; (3) the carriage is shifted in left-hand extreme position after which the handle *3* is pressed and turned to the right until the finger *4* passes into the horizontal slot of the carriage *5* as far as it will go; (4) the handle *1* is brought out of the slot and as a result the friction disk *2* is pressed to the cone *8*. At machine operation the carriage *5* is displaced to the right along the screw *7* together with the friction disk which actuates the counter and tachometer.

Drum starting mechanism. The proper position of the mechanism elements is adjusted by pressing the treadle *1* (Fig. 109*a*). The treadle plate must be 4-5 mm higher than the deck. The rest *3* provided in the bracket *2* must press on the lever *10* (the lever is shifted under the rest *3* by means of screws *4* and *5*) which resting on the finger *9* turns together with the lever *8* and shaft *7* over about 8° from the horizontal (20 mm), this being achieved by setting the rest *3*. The lever *6* turns the drum brake lever causing drum unbraking. The vertical arm of the lever *1* (Fig. 109*b*) moves behind the plate *2* and fixes in place the starting and braking systems. To avoid the action of the pawl *4* on the lever *1* at starting, it is necessary

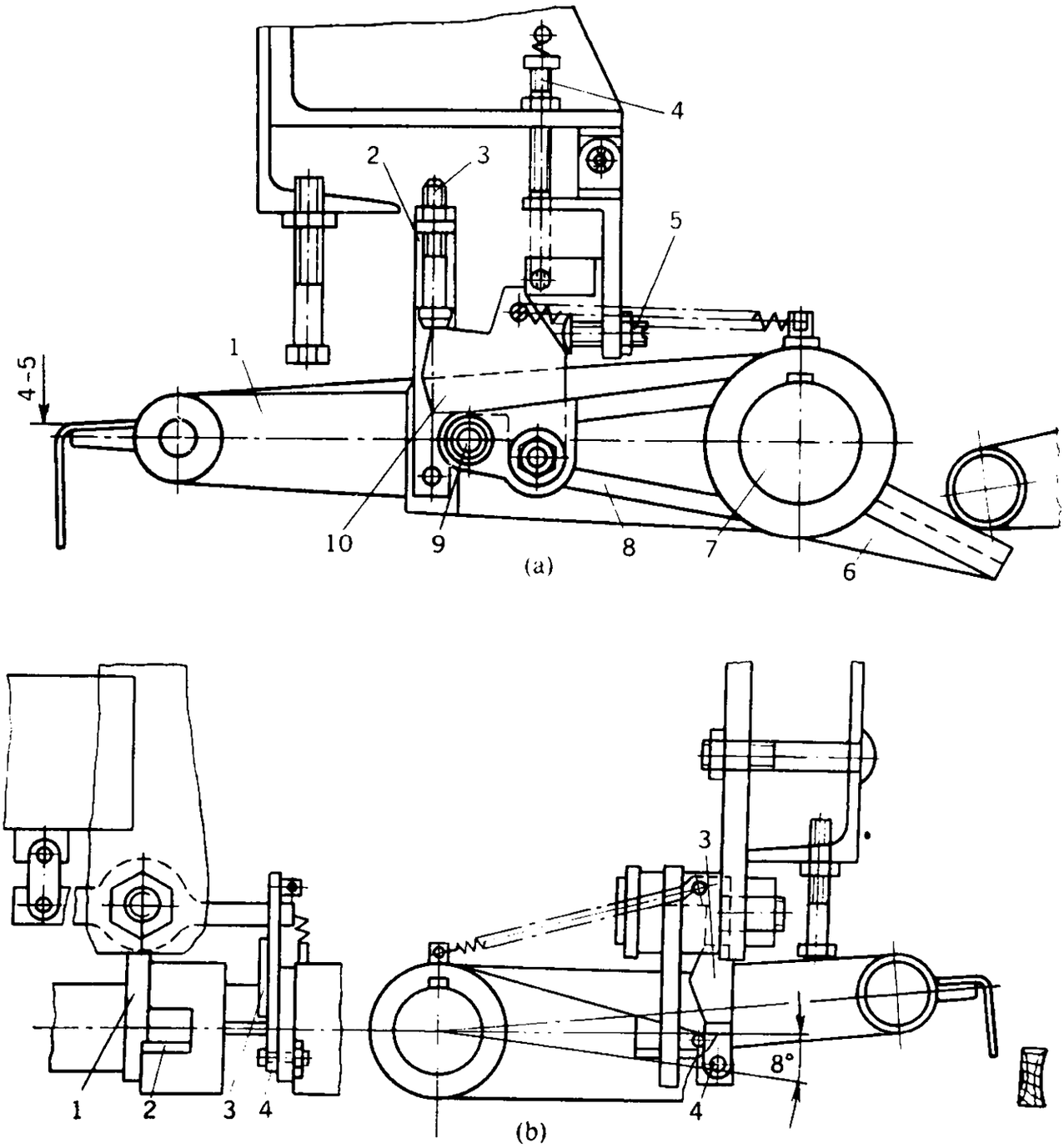


Fig. 109. Section warper drum starting mechanism

to set the rest *3* so that the pawl *4* goes past the lever *1*. On repeated pressure of the treadle the pawl *4* must engage the lever *1* and bring it in disengagement with the lever *8* (see Fig. 109*a*). At this time, under the action of braking springs (not shown in the drawing) the drum brake lever turns all the systems in reverse direction and the mechanism will be ready for starting. The general stroke of the lever *8* is about 11 mm.

Warping table. The warping table is mounted on the top guide *1* (Fig. 110*a*, *b*) of the machine-framework. The lead screw *1a* is to be set parallel to the drum cylinder generatrix by shifting the left-

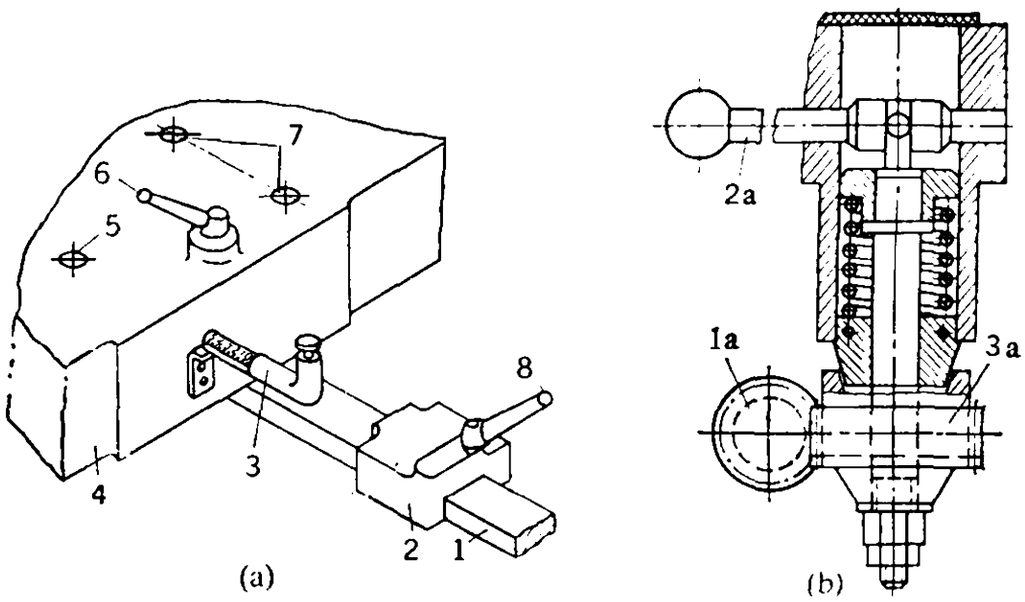


Fig. 110. Warping table of section warper
(*a*) warping table arrangement; (*b*) lead screw adjustment

hand bearing. The engagement of the gear *3a* with the lead screw must be without oscillation but not tight. The adjustment is effected by displacing the guide *1* and turning the eccentric fingers *7*. The carriage *4* of the warping table should not oscillate. The clearance between the guide *1* and bearings attached on fingers is adjusted by turning the eccentric finger *5*. The warping table can be displaced over the entire length of the guide. The engagement and disengagement of the gear *3a* with the lead screw *1a* is effected by turning the lever *2a*. When the gear is engaged with the lead screw the warping table to which a force of 700 N is applied cannot be displaced along the guide.

When the first section is processed, the warping table is set so that the extreme yarns accurately coincide with the beginning of the drum cone. For this, the rule *3* must be released by turning the lever *6* and fixed again after setting at a distance equal to the section width. To avoid overlapping when warping yarns of synthetic fibre the rule is placed at a distance much superior to the section width (as determined in practice). In this case, the slider *2* must be released by turning the lever *8* and fixed again according to the guide. When placing the following section, the carriage should be brought up to butting against the slider *2* and fixed in place. The slider *2* should be set in the same way as when processing the first section. When laying the leases the frame with guiding rods should be collapsed in back position to allow all the yarns to assemble in one section. Then, turning the handle the lease reed is to be raised or lowered for forming a shed. The reed must easily move and must be balanced with weights.

Beaming mechanism. For weaver's beam installation, it is necessary to proceed as follows: shift the complementary stock *3* (Fig. 111) in right-hand extreme position (by the flywheel or manually). Using the flywheel *5* put the gear out of meshing with the worm *6*; insert the weaver's beam pin in the stock bushing, and bring the second (driving) stock *2* close to the weaver's beam. Both stocks are to be joined together by the strap *4* and the weaver's beam adjusted according to the warp width, i.e. the weaver's beam disks should be set opposite the width of the top winding layer on the drum and the ends of the warp are to be threaded on the weaver's beam. It is necessary to check that the switch "Warping"—"Beaming" is set at the mark "Beaming". Adjust the counter and shift away the levers for rolling-out the weaver's beam. The treadle should be depressed, and using the microscrew *1* the weaver's beam must be adjusted according to the warp, after which using the flywheel the gears are to be engaged with the worms. The weaver s beam may be stopped by actuating the treadle or by the counter after the predetermined length of warp has been produced.

Weaver's beam starting mechanism. The coupling disks must be compressed and the lever *10* (Fig. 112*a*, *b*) must bear with its vertical arm against the strap *7*. When the pedal *6* is in bottom position, the clearance between the pedal rings and the bottom channel (tie) must be 3-4 mm. The pressing ball *4* must be set so that the pawl *5* would lower and press on the finger *9*. The pawl *8* must deviate from the horizontal arm of the lever *1* which is obtained by the displacement of the boss on the pawl *8*. The head of bolt *2* must be 35 mm away from the lever *3*, while the lever itself must be in vertical position. At the second lowering of the pedal the pawl *8* must engage the lever *10* and bring its vertical arm out of engagement with the lever *1*, thus causing the coupling disengagement. In the event of coupling disk wear, the dimension 122 between the axes of the ties must be reduced.

Construction of magnetic clutches. The reducer change-over mechanism is a device with two magnetic clutches consisting of a shell, a pack of friction disks, and an armature.

The coil is attached in the slot of the shell by means of a grouting mass on the basis of epoxy resin. A plastic insulation ring with a pressure-fitted contact ring inside it is mounted on the clutch shell. The reliable fixing of the insulation ring on the shell is ensured by knurling the seating surface, the use of epoxy resin glue and cylindrical pins. The contact ring is made of steel hardened to Rockwell C 60-62 and reliably joined with the insulation ring made of fabric-based laminate or glass reinforced plastic. One outlet wire of the coil is soldered to the butt face of the contact ring and the other to the clutch bobbin.

Friction disks are made of steel with a hardness of Rockwell C

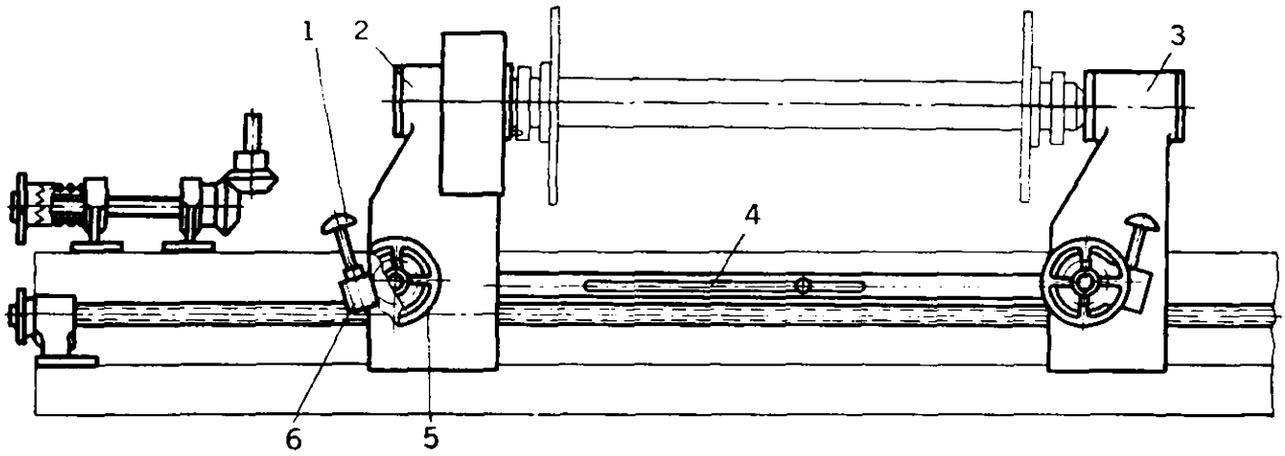
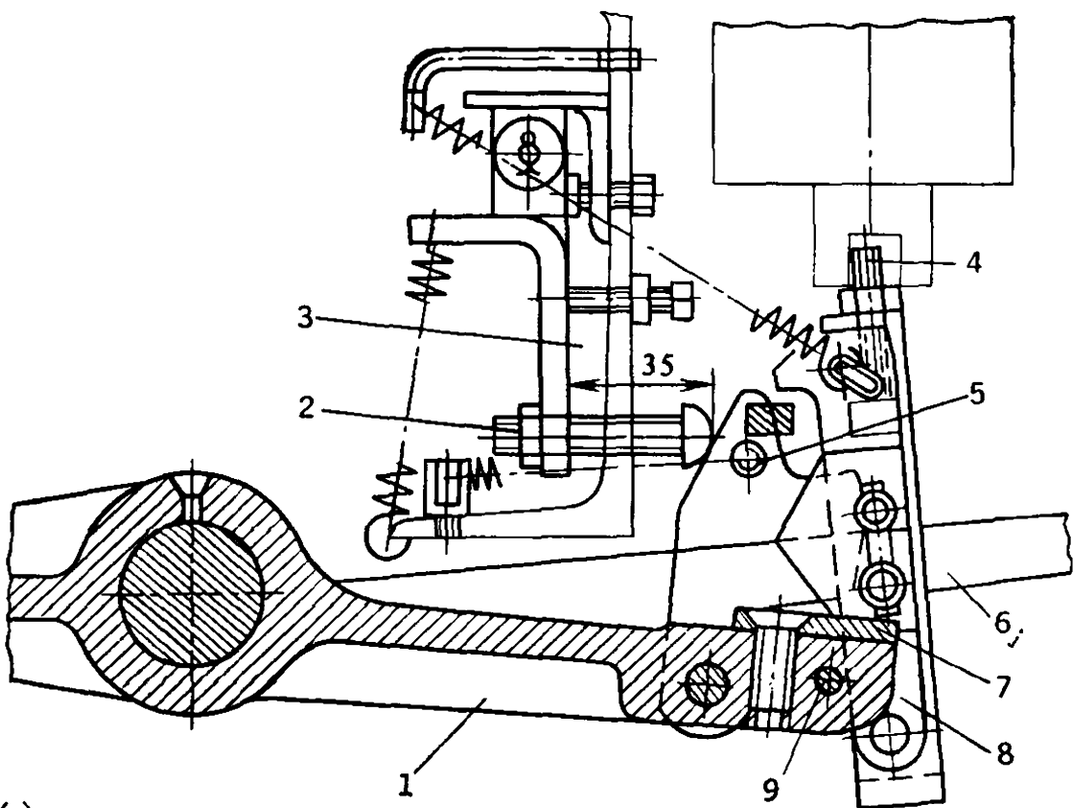
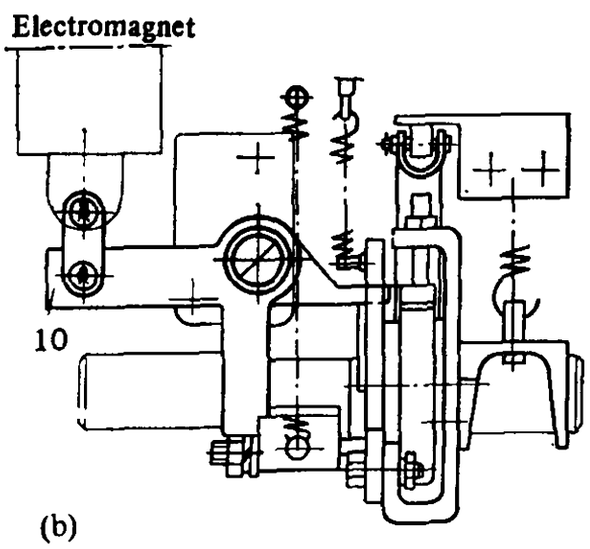


Fig. 111. Device for warp beaming from drum to weaver's beam



(a)



(b)

Fig. 112. Weaver's beam starting mechanism

(*a*) diagram of clutch engagement; (*b*) weaver's beam starting mechanism (front view)

40-45. Provided between the inferior disks are wave-shaped springs releasing the friction disks on clutch disengagement.

The clutch armature consists of three parts. The interior bronze bushing insulates the armature from the shaft owing to which the dispersion of the magnetic flow through the shaft is reduced and the armature can freely move on clutch engagement and disengagement. The bronze bushing is pressure-fitted into the interior armature ring with which the exterior armature ring is joined with a clearance fit.

This design, ensures tight adherence of the armature to the friction disks and compensates for the possible irregularity in the thickness of the pack of friction disks at the level of the inside and outside diameters.

Maintenance of the magnetic clutches. It is guaranteed that at a rotational speed of 500 min^{-1} the clutch will make at least two million switchings. In this case, the disk wear is 25% from the initial mass which is to be considered as the maximum admissible value. A greater wear is dangerous for the disk strength.

The clutch is lubricated with industrial oil. Prior to filling the oil, the clutches as well as the tank must be carefully cleaned from fine chips, cast iron dust, etc. From 8 to 9 litres of oil are to be filled into the reducer, and the magnetic clutch disks must be immersed to 15-25 mm in the oil. The disk cooling and oiling would be much worse for the low oil level. The examination of oil condition and its level is done with the reducer cover removed and the machine at standstill. The lubricant oil ages quicker with the operation of units equipped with clutches than with gearings. For this reason, it is necessary to take care that the oil temperature in the tank does not exceed 50°C and should be maintained within the limits of 30-40°C. During the work it is necessary to establish the most adequate regularity of oil replacement. The brush wear should also be periodically checked by determining the travel remaining in reserve. For this, the brush holder is unscrewed one turn and the broken contact (no voltage) means that the central part of the brush holder must be replaced. The brush can be made of brass ribbon and fine net wound into a roll.

The sequence of clutch assembly. The clutch operation greatly depends on the sequence in which the disks and spring washers are to be installed. First, the movable armature is fitted on the shaft and upon it in consecutive order: the external friction disk, the internal disk, then again an external disk carrying the first spring washer, and so on. The last internal disk is placed on the external disk and spring washer, and the clutch coil is put in place. It is not allowed to use deformed disks. The disks prior to installation are checked on a smooth flat plate without dents and scratches and distorted disks must be straightened. The armature free stroke must

not exceed 5 mm. A greater travel of the armature increases the time for putting the clutch in action and bringing the machine to speed at starting. An increased free travel of the armature may be the cause of its misalignment on the slotted bushing, the non-engagement of the clutch and the overheating of its disks. For reducing the armature travel before its installation, a flat ring of any antimagnetic material (bronze, aluminium, fabric based laminate, etc.) of adequate thickness is fitted on the shaft.

Lubrication. The lubrication is carried out according to the chart (Table 8) and the functional diagram. The holes for liquid oiling

Table 8. Lubrication Chart of the Mechanisms in a Section Warper

Mechanism	Lubricant	Number of oiling points	Lubrication method	Periodicity of lubrication
Framework	Industrial oil	2	Hand oiler	Once a week
	Cup grease	12	Replacement in body	Once a year
Drive	Industrial oil	15	Hand oiler	Once a week
	Cup grease	1	Grease gun	Once a month
Drum brake	Industrial oil	8	Hand oiler	When necessary
Warping table	Industrial oil	8	Hand oiler	When necessary
	Cup grease	8	Replacement in body	Once a year
Drum starting motion	Industrial oil	6	Hand oiler	Once a week
	Cup grease	2	Grease gun	Once a month
Feeding mechanism	Industrial oil	10	In tank	When necessary
Rebeaming mechanism	Industrial oil	12	Hand oiler	Once a week
	Cup grease	20	Grease gun	Once a month (replace once a year)
Weaver's beam starting mechanism	Industrial oil	10	Hand oiler	Once a week
Spare parts	Technical petrolatum	—	—	Once a year

must be clean and the excess of lubricant must be eliminated. The amount of grease packed in ball bearings must be equal to about 3/4 of the free space in the bearing shell. Special attention must be paid to the oil condition in the reducer with electromagnetic clutches and in the variator. Even if the oil becomes slightly opaque it must be immediately replaced. For the first time oil is replaced after 200 h of work. At oil replacement the mechanisms must be washed: the reducer—with clean kerosene, and the variator—with washing oil of low viscosity (as for instance velocit). Washing is to be carried

out as follows: (1) for the reducer—discharge the used oil and through the top cover fill clean kerosene in an amount equal to that of the filled working oil; run the reducer for 3-5 min and discharge the washing oil through the outlet, fill the fresh oil and run the reducer again for 5-10 min; (2) for the variator—discharge the used oil, and through the top cover fill the washing oil in the amount equal to that of the filled working oil. Run the variator for 5-10 min and discharge the washing oil through the outlet opening, fill the fresh oil and run again the variator for 5-10 min. For lubricating the variator and reducer use industrial oil. Open gearings are to be lubricated with cup grease at least once a week.

The screws forwarding the working table and weaver's beam, the counter screw and the guides of the working table and of weaver's beam are oiled with rags soaked in industrial oil; articulated joints and chains, with the exception of driving ones, are lubricated with a hand oiler after each machine cleaning, at least once a week. The drum and weaver's beam driving chains (double row) must be removed from the machine every three months, washed in benzine and immersed in melted cup grease for 5-10 min.

Checking the technical condition of the machine. After the assembly, erection, and adjustment of machine mechanisms it is necessary to check the technical condition and the service ability of the mechanisms. The list of inspections and checkings to be performed is given below.

Idle running-in	At least 2 h of continuous operation
Cooperation and positive action of mechanisms and controls	—
Stoppage of drum and weaver's beam from treadles, push buttons "STOP", from counter and creel signal frames	At least 10 stoppages
The position of braking belts on the drum pulleys	In unbraked condition sections must not contact pulleys
Chain tension	Chain sagging should not exceed 0.02 A (A—spacing between centres)
Amount and quality of oil in drive speed variator and reducer (every week)	Dark oil must be replaced. Oil amount is checked with an oil indicator
Surface condition of variator cone counter	Surface must be dry

REVIEW QUESTIONS

1. What are the requirements set towards the framework of a warper?
2. What is the purpose of a warper drive?
3. What is the purpose of the condensing roll and how is it designed?
4. Explain the arrangement of the warper's beam.
5. What is the difference between beam and section warpers?
6. What is the purpose of tail spindle in a section warper?

7. How are current repairs of warpers carried out?
8. Discuss medium repairs of warpers and their peculiarities.
9. How is an overhaul of warpers carried out, and what are its peculiar features?
10. How is the warper lubricated? Describe the kinds of lubricants used and the lubrication routine.
11. What are the functions of the starting and stopping mechanism?
12. What is the purpose of the braking mechanism? What are its peculiar features?
13. Discuss the adjustment of a beam warper.
14. Discuss the adjustment of a section warper.
15. Describe the main kinds of defects on a warper and the measures for their elimination.
16. Describe the main disarrangements in a section warper and the measures for their elimination.

2. Sizing Machines

The sizing machines are intended for applying the size on the warp yarns, squeezing out the excess of size, drying the warp yarns and winding them on the weaver's beam with preset density. These machines are complex ranges equipped with devices for the automatic adjustment and control of processing parameters. The main parts of any sizing machine are: the creel for warper's beams (or weaver's beams); the framework and drive; the sizing unit, the drier, the separating rods and reed for separating the glued warp yarns; the winding mechanism, the measuring and marking mechanism, complementary arrangements (emulsifying unit or waxing unit); the automatic devices for controlling the sizing process and maintaining preset parameters.

The sizing unit consists of the size box, squeezing rolls, and immersion device. It may have one or two couples of squeezing rolls. The sizing boxes in the main are without size circulation with the exception of machines for sizing man-made yarns and yarns from a blend of man-made fibres.

The *drying unit* is the main part of the sizing machine that serves for drying sized yarns. Drying of yarns in the drier is done by the contact, convection, or combined methods. Depending on the drying method employed, the sizing machines are classified into cylinder, hot air, combined, and special sizing machines. Most largely used in the cotton, flax and silk industries are cylinder sizing machines (from 2 to 13 cylinders). The cylinders are arranged in two vertical rows. The cylinders which are the first from the sizing box have antiadhesive coatings. Hot air sizing machines are most widely applied in the flax and woollen industries; in these machines the sized yarns are dried with hot air. Combined sizing machines were

manufactured before for the silk industry. Sizing machines in which special drying methods are employed (high-frequency currents, ultraviolet rays, and gas) have not yet found wide practical application.

The sizing machine is prepared for repairs by cleaning it from threads, disengaging the steam supply and discharging the size. The following operations are carried out during medium and overhaul repairs of sizing machines.

Medium repairs. Medium repairs of mechanisms are the same both for cylinder and hot air sizing machines and include the following jobs:

replacing the worn-out bearings of the warper's beams pins, repairing devices for longitudinal displacement of bearings, checking the frames setting and fastenings;

cleaning and examining the size trough, and carrying out necessary repairs;

examining the guiding rollers, draw roller, skeleton roller, the mechanism for lifting and lowering the skeleton roller and making required repairs;

taking off the squeezing rolls, checking the copper jackets for proper fastening and examining the rollers, the glands and bearings, machining the worn-out shaft necks, repairing all faulty parts, removing the old coating from the top squeezing rolls, cleaning the rolls and painting them with white then placing a new coating, inspecting the squeezing roller lifting mechanism and making necessary repairs;

checking the condition of the parts in the measuring and marking unit and the counter;

removing winding and examining the delivery roller;

disassembling and examining the friction clutch, and repairing its parts, replacing gaskets between the friction clutch disks with new ones that must be oiled and rubbed with graphite prior to their installation, replacing the felt and checking the belt braking;

dismantling and examining the equalizing mechanisms, the differential and speed box, and making necessary repairs;

checking the parts of the pressure arrangement;

ascertaining that the guards are in place and in good order, examining and cleaning all the gearings, and replacing worn-out gears;

checking the condition of belt drives and making necessary repairs, dismantling the drive for idle and slow run of the machine and making necessary repairs, examining and repairing the speed variator;

examining the guiding rollers, their bearings, straightening bent and crushed rollers, repairing the worn necks and replacing worn-out bushings;

examining the bearings of machine rotating parts, and after the elimination of defects, washing and lubricating them;

packing the bearings and grease cups with fresh grease;

checking the operation of the reducer, safety valve, pressure gauge, and their three-way cocks;

examining the pipelines and checking devices, eliminating leakages and steaming in pipe connections, and lapping all faulty valves and inserting the glands;

examining and repairing automatic devices, such as thermoregulators, level and humidity regulators, including the electrical wiring.

When repairing drying cylinders it is necessary: to examine their bearings and necks, to eliminate the defects, to wash the bearings and to fill them with fresh oil; to examine the drive of the drying cylinder, to check the condition of gears, the operation of buckets in drying cylinders and to repair the faulty ones; to check the condition of the drying cylinder surface and the shell fastening; to check the operation of safety and air valves in the cylinder bottoms; to replace the grease in the glands of drying cylinders; to examine, to clean, and to repair the steam traps; to inspect the cover of drying cylinders and the hood above the sizing trough; to make necessary repairs; to repair the insulation of the drying cylinder bottoms and steam lines.

When repairing the drying chamber of sizing machines it is necessary; to examine and repair the reels; to check the windmill operation, to inspect the fixtures and condition of blades; to check the operation of the exhaust fan; to examine the air heaters and to replace the faulty ones; to replace the gaskets with steam leakage; to examine the cover of the drying chamber and the hood above the sizing trough and to make necessary repairs; to examine the guiding rollers and to clean them from clogged dirt; in hot air sizing machines—to examine the heating and ventilation systems, the nozzles, ducts, air heaters and filters and to make necessary repairs.

The list of operations carried out at medium repairs is not full and depending on the kind of machines it must be established more precisely. For example during medium repairs of a hot air sizing machine the following jobs are carried out: the repair of the friction clutch, reducer and speed variator with partial dismantling; the inspection of the working condition of reels, cylinders and wind mills checking the fixtures of the reel ties and the blowers for run-out; dismantling the squeezing rolls and checking the axle boxes, links and drawing rolls; examining and adjusting the creel for warper's beams; repairing the reed and counter; checking the good sealing of air heater and steam line connections; checking the size line and coils; repairing the wooden panels of the machine hood; examination of the condition of exhaust fans with their disassembling, washing and lubrication of ball bearings and of the machine.

In a cylinder sizing machine the following additional jobs are carried out: the differential is repaired with partial dismantling, the cylinder man-holes are opened, the pouring ladles are examined, the pressure vacuum belts are lapped, the working condition of glands is checked and the grease is replaced.

Overhaul. During overhaul repairs it is necessary:

to disassemble and examine the entire machine, to clean and select the parts which are not fit for repair;

to check the condition of frames of warper's beams, the size trough, the drying cylinders (or drying chamber), the front part of the machine, and to ascertain their proper installation using a plumb bob and a water level as well as their reliable fastening (the frames must be mounted strictly symmetrical to the machine axis);

to take out the perforated pipes from the size trough, to disassemble the pipelines, to clean and repair them; to examine the size trough and if necessary to repair it;

the bent rollers, shafts and the skeleton rollers are to be straightened and checked on a lathe.

In case of cavities and defects on the surface of the bottom squeezing rolls the latter must be turned and ground (as considering that the roll diameter will be reduced, it is necessary to use another drive for maintaining the same speed of the rolls), the felt must be removed from the top squeezing rolls, the surface must be cleaned, coated with white paint, and the rolls must be covered with new felt;

to put in place the drying cylinders, check the proper installation of the cylinder with a water level and the parallelism of the rolls to each other and in respect to the squeezing roll (the bearings must be packed with fresh grease and the cylinders must easily turn in the bearings), check the proper fixing of the toothed gear sectors on the cylinders and the correct balancing of drying cylinders;

to examine and repair the ladles and safety devices of the drying cylinders;

in sizing machines with air drying, the reels and fans (blowers) are to be put in place and the bearings filled with fresh oil. In hot air sizing machines it is necessary to examine and repair rollers, ventilation and heating devices (nozzles, ducts, filters, air heaters), to examine the heating batteries and to replace the faulty ones;

using a level to install the side shaft with gears parallel to the machine centre line;

to check the conical driving pulleys, the condition of the necks and fixing of gears on the shafts and to install the shafts in place;

to inspect and repair drives for transmissions, conoids and slow running. In transmissions with a speed variator, it is necessary to repair the variator, the centrifugal clutch, and the slow-speed reducer;

to repair the delivery roll and install it parallel to the squeezing roll and drying cylinders;

to examine and if necessary repair the equalizing mechanisms and the speed boxes;

to carry out the repair of counters, pressure mechanisms reeds and emulsifying unit;

to repair guards and air ducts;

to check and repair the steam lines, the flange connections and the insulation of the drying cylinder pipelines;

to take off the pressure gauges, to send them for checking and to return them in place after checking;

to return in place after examination and repairs the reducer, the safety valve and steam traps, the temperature and size level regulators, as well as the humidity regulators;

to fill the oilers and to lubricate the entire machine;

to check the condition of the electrical equipment, the wiring of starting devices, the groundings, etc.

after machine assembly is completed it must be tested at slow running, the defects must be eliminated and the whole unit must be checked after which the machine must be tested at working speed. The list of overhaul operations is not complete and when compiling the list of defects for repairs, modifications may be introduced taking into account the type and condition of the equipment.

Characteristic faults in sizing machines and methods of their elimination are given in Table 9.

Cylinder Sizing Machines

Modern cylinder sizing machines (of the beam and section type) consist of the following units and mechanisms: the creel for warper's beams (beam warper's sizing machines) or creel for the weaver's beam (section warper's sizing machines); the lease rod mechanism; the sizing unit; the cylinder drier (7-9 cylinders); the steam and condensate line; the lease rod field and the delivery unit.

The creel for warper's beams is made of rolled steel and accommodates 8-12 beams with a flange diameter up to 800 mm. The braking of warper's beams is effected by elastic brakes arranged on the outside diameter of the beam flanges. During creel repair, the rigidity is restored by welding the defectuous places, the brakes are adjusted and if necessary the braking belts and springs are replaced.

The lease rod mechanism is intended for separating the warp yarn and laying between them lease rods; it consists of the rack for the lease rods and the reed. During the repair of this mechanism, the faulty reed is replaced by a new one. If the worn reed may be repaired it is restored by soldering the teeth, and if the feed is worn out it is replaced with a new one.

The sizing unit is intended for impregnating warp yarns with size and their further squeezing to obtain the required humidity by

Table 9. Characteristic Faults in Sizing Machines and Methods of Their Elimination

Description of faults	Causes	Methods of elimination
Excessive warp tension and stretch at the entry into sizing bath	Braking of warper's beams is too strong due to misalignment of insert shaft pins	Install properly the warper's beams or inserts
	Clearance between braking disks and magnets is impaired	Clearance must be equal to 0.1 mm
	First equalizing mechanism is improperly adjusted	Turn pointer of equalizing mechanism to the right until required tension and stretch of warp is obtained
Warp tension is slack	Equalizing mechanisms are not properly adjusted	Set equalizing mechanisms according to machine certificate
	Clearance between magnets and braking disks is impaired	Clearance must be equal to 0.1 mm
Jerky running	Shafts of insert pins in warper's beams are askew	Set properly the warper's beams or inserts
	Misalignment of warper's beams in creels	Set properly the warper's beams in creels
	Improper shape of warp winding on warper's beams	Warper's beams must be replaced with new ones having correct warp winding
	Warper's beam and weaver's beam flanges are askew	Using a wooden hammer eliminate the misalignment
Irregular squeezing of warp	Different length of lever drawbars in pneumatic system	Using a coupling connecting upper and bottom halves of drawbars adjust the drawbar length
	Air chamber membrane is deteriorated	Replace the membrane
Insufficient warp squeezing	Air pressure in pneumatic system is too low	Check for leakage of compressed air; in case of leakage—eliminate it
Roping or sloughing of warp	Pneumatic chamber membranes are damaged	Replace the membranes
	Immersion roller is not parallel to squeezing rolls	Raise or lower one of racks of the reel lifting mechanism. Non-parallelism should not exceed 1 mm

Table 9 (*continued*)

Description of faults	Causes	Methods of elimination
	Immersion roller turns with difficulty due to misaligned or defective bearings	Eliminate the misalignment, replace the bearings
I regular rotation of beams	Misalignment of warper's beams, immersion roller, drying cylinders and drawing couples	Eliminate the misalignment
	Surface of rubber-coated rollers is worn	Grind the rollers
	Yarns are not properly placed in the reed	Carefully check spreading of yarns in the reed
Warp is shifted aside	Non-parallelism of rollers	Check and adjust the rollers
Sagging of warp between drying chamber and draw-off unit	Run-out of drums due to long stroke of spring in drive tension arrangements	Tighten the springs
	Driving chain is loose	Tighten the chain
Clatter in chain transmissions of squeeze roll drive	Chains of squeeze roll sprockets are slack	Eliminate slackness by means of tension sprockets
Condensing beam fails to be expanded	Indentations in slots of condensing beam	Eliminate the indentations
	Angle of pressure rollers in warp condensing mechanism is improperly adjusted	Adjust the angle of roller installation
Breakage of selvedge yarns in winding onto weaver's beam	Burrs on weaver's beam flanges	Eliminate the burrs
	Excessive axial play in flanges	Replace the beam
Warp edges are loosely wound on the weaver's beam	Length of pressure beam does not correspond to distance between the weaver's beam flanges	Length of pressure beem must correspond to distance between weaver's beam flanges
Warp edges on weaver's beam slip down	Weaver's beam flanges are loosely fixed	Weaver's beams with loose flanges should not be used
Warp tension changes in jerks	Driving chains overshoot sprockets	Tighten the chains

Table 9 (*continued*)

Description of faults	Causes	Methods of elimination
	Overshooting of cam clutch in weaver's beam drive reducer	Adjust position of semi-coupling. Grind cams and ensure reliable fixing of changeover lever
Pulsation of warp tension in lease rod field and periodical sagging of warp	Abutment or end pressure of condensing beam on weaver's beam flanges is too high	Adjust the inclination of rollers
	Alternating load in driving and driven branches of chains between drawing rolls and side shaft	Tighten the chains
	Rollers of over-running clutch on delivery roll are wedged	Check the clutch
	Jamming in weaver's beam members	Check and clean chain drives, gearings and face plate guards from foreign articles
Sagging of warp in lease field at machine stoppage	Overrunning clutch on delivery roll fails to operate	Check the clutch
Back spindles do not move though motor operates	Spring of safety clutch is loose	Tighten the clutch
	Weaver's beam setting mechanism transmission is damaged	Eliminate the damage
When warp ends are drawn for tying to weaver's beam, drawing roll does not rotate (it is necessary to apply manually an additional effort) or roll rotates, but warp remains stationary	Pressure roller is insufficiently or not at all pressed to delivery roll	Check condition of pneumatic chambers, three-way cock and pneumatic ducts to pneumatic chambers
Leakage in sizing tank	Gland packings are worn out	Replace them
Leakage in connections of steam-and-condensate pipe	Gland is insufficiently packed	Replace the gland
	Nuts are not tight	Tighten the nut
Size overheating	Thermoregulator does not operate properly	Adjust the thermoregulator

Table 9 (*continued*)

Description of faults	Causes	Methods of elimination
	Steam check valve in closed position lets steam pass through	Check and eliminate the fault
Required size level is not maintained in tank	Operation of size level regulator is impaired due to formation of film between electrodes	Eliminate the film
Insufficient drying of warp. Speed of warp motion is reduced	Accumulation of condensate in drying cylinders due to clogging of condensate drain filters	Clean the filters
	Insufficient pressure in pipeline. Steam check or reduction valve are out of order	Check and eliminate the fault
Condensate drips from the ceiling	Exhaust ventilation is not powerful enough	Make adjustments so as to obtain required intensity of air exhaust from drying chamber by means of slide valve (according to adopted drying conditions)
	Connections of steam lines are unreliable	Tighten the nuts of connections
Machine operates only at threading speed and cannot be switched over to working speed	Guards of draw rolls are not tightly pressed, end switches do not operate	Check the end switches and reliable action of rests
	Relay fails to operate	Check relay and clean contacts
Motor of weaver's beam or side shaft does not rotate; convertor unit, exhaust fan, back spindle, and fan drives do not work	Starter is not under voltage	Check voltage on starter terminals
	Starter thermal protection has come in action	Return thermal relay button into initial position
	Safety fuses are burnt	Replace the fuses
Engaged for "Threading", machine quickly reaches maximum speed and cannot be controlled. Warp tension on weaver's beam is normal or without considerable deviations. Pointer of ammeter controlling load of side shaft generator goes off-scale	No current in windings due to breakage in bias circuit, and the absence of voltage at the output of rectifier	Eliminate breakage in bias circuit. Check voltage at input and output of rectifier. If there is no voltage locate and eliminate the fault. Check current in the winding circuit

Table 9 (*continued*)

Description of faults	Causes	Methods of elimination
	Breakage in velocity feedback circuit (the machine cannot operate at maximum speed)	Eliminate breakage. Check current supplied from output to input. Check current in the winding circuit
	Breakage in output (input) circuit	Eliminate the breakage
	Safety fuses in feeding circuit are burnt	Replace the fuses
On engagement of rotary switch on main board, the weaver's beam driving motor sharply changes its speed which causes warp yarn breakage	Breakage in current feedback circuit	Check current in the feed-back circuit
	Breakage in output (input) circuit	Eliminate the breakage. Check current supplied from output to input. Eliminate the breakage
Pointer of ammeter controlling the load of weaver's beam drive generator goes off-scale at starting and returns close to zero	Safety fuses in supply circuit are burnt	Replace the fuses
On engagement for "Threading" the machine does not work	No voltage in circuits	Check voltage in control circuits. If there is no voltage, locate and eliminate the fault
	No voltage in excitation winding of side shaft generator	Check voltage on excitation wiuding of generator. If there is no voltage, locate and eliminate the fault
	Safety fuses in motor armature circuit are burnt	Replace the fuses
On engagement for "Threading", weaver's beam does not rotate	No voltage in excitation winding of weaver's beam drive generator	Check voltage on generator's excitation winding and if there is no voltage, locate and eliminate the fault
	Safety fuses in motor armature circuit are burnt	Replace the fuses

Table 9 (*continued*)

Description of faults	Causes	Methods of elimination
Warp tension in the delivery roll-weaver's beam zone deviates from normal	Diameter sensor (selsyn) is not properly adjusted or out of order	Check proper adjustment of selsyn and if necessary bring corrections
Machine speed is unstable and considerably deviates from preset values	Jamming in machine mechanisms	Locate and eliminate jamming
	Parameters of correlation circuits are changed both in the circuit of side shaft and in the weaver's beam driving circuit	Check parameters of stabilizing circuits Elements presenting deviations from nominal values must be replaced

means of squeezing rolls. The sizing unit consists of the framework, the tank for the size, the tank lifting mechanism, the immersion and measuring rollers, the top squeezing rubber-coated roll and the bottom squeezing metal roll (the driving one). A special tank with a size pipeline is provided for size circulation.

The framework is a structure made of two cast-iron stands mounted on a common welded frame of rolled steel, these stands being braced together. The framework carries all the assemblies and mechanisms of the sizing unit. Arranged inside the stand guards are the mechanism for lifting and lowering the immersion roller and the control panels of the tank lifting mechanism and of the squeezing roll pressure mechanism. During repair of the framework its rigidity is restored by welding the defectuous points.

The size tank is made of stainless steel sheet. A special mechanism consisting of a double-stroke pneumatic cylinder and a leverage system ensures its lift and lowering. The tank is filled with size through two branch pipes of the size duct and also from the system supplying the size in the roller nip. The tank design ensures a constant circulation of the size, i.e. the size coming into the tank from the reservoir reaches the level of the tank edge and overflows into the discharge opening, after which it is returned into the reservoir via the discharge mains. For discharging the size remaining below the level of the tank edge, an outlet is provided in the tank which is connected by pipelines with the circulation tank and the sewage. The size remaining in the tank may be discharged back into the reservoir and the water after washing—into sewage. The aim of tank repairs is to eliminate possible leakages. After repair (welding) the joint tightness is checked by flooding the tank with water and the circulation pump and size duct are cleaned.

The immersion roller (130 mm in diameter) is made of stainless steel and mounted in sliding friction bearings which are connected with the racks of the immersion roller lifting and lowering mechanism. The racks are actuated from the drive consisting of an a.c. motor and a worm reducer. The top and bottom positions of the immersion roller are fixed by end switches through the intermediate of two rests mounted on the right-hand rack. If necessary the bearings are replaced and the rack and rests are repaired.

The top squeezing roll made of a steel pipe with an elastic rubber coating is mounted in antifriction bearings on the pressure mechanism levers. The top squeezing roll is pressed to the bottom one through a leverage system from two pneumatic chambers. A special locator is provided for fixing the roll in upper position when the machine is stopped for a long time.

During the operation of the sizing machines cavities are formed on cast iron squeezing rolls which renders difficult the squeezing of warp yarns. To avoid this defect the roll is usually turned on a lathe,

Fig. 113. Method of repairing squeezing rolls of sizing machine

but after the second turning the rolls must be replaced by new ones. It has been suggested to fill the cavities with aluminium. For this, using a chisel, a hole is made at the point of the cavity and an aluminium rod of adequate diameter is inserted in this hole and riveted over (Fig. 113). This done the riveted cavity is filed.

The size circulation tank is made of stainless steel and consists of an exterior bath with an interior bath inserted into it. A coil with blind steam is arranged in the space between the two baths which is filled with glycerin (the latter being a heat carrier ensuring the uniform heating of the size in the tank). The repair of the tank comes to the restoration of its tightness. After repairs, the tank and coil are checked for good sealing.

The cylinder drier is intended for drying the warp to be impregnated with size and squeezed. It consists of the framework, several drying cylinders (5, 7, 9, 11 and more), two transfer rollers, a steam and condensate pipeline and the drying cylinders drive. The transfer roller at the entry into the drier and the first four or three cylinders have an antiadhesion coating (Teflon, fluoroplastic) to avoid the adherence of the size on the surface.

The drier framework is a structure made of cast iron stands connected together by braces. The framework carries all the units and mechanisms of the drier.

The drying cylinder (Fig. 114) consists of the shell *7* made of steel sheets. Elliptical bottoms *6* are welded to the shell and have flanges to which the journals *3* are attached. Provided on the left-hand journal is the silphon seal *4* for supplying the steam and elimination of the condensate, while on the right-hand journal there are the vacuum valve *2* and the driving sprocket *1*. All drying cylinders are rotated by means of chain drive. In the bottom of the cylinders a discharge cock is provided for the elimination of the condensate.

During repairs, a check is made on the drying cylinder ladles, the vacuum valves and the discharge cocks; the manholes of the cylinders are closed. When carrying out any work inside the drying cylinder measures are taken to avoid unrestricted supply of steam or condensate into the cylinder, i.e. the steam line and condensate lines are disconnected from the cylinders and reliable locks are provided on starting valves. The bearings are washed (one of the bearings must have an axial clearance of 4-5 mm so as to allow the free elongation of the cylinder shaft on heating). The balancing of cylinders is checked at the site and the insulation of their butt faces is restored.

The delivery part of the machine consists of the framework, the ribbed roller, the delivery roll, the measuring and pressure rollers,

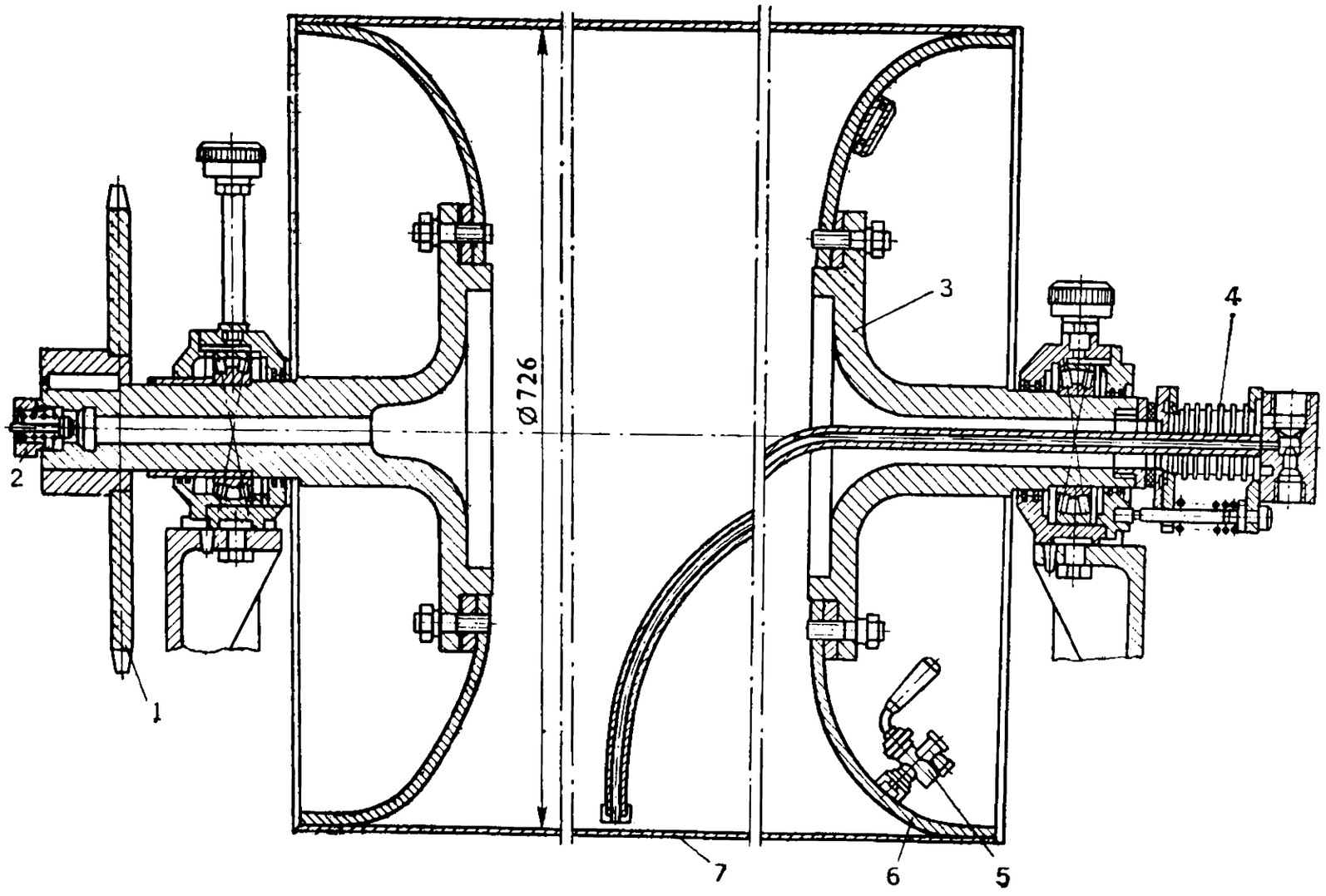


Fig. 114. Sizing machine drying cylinder

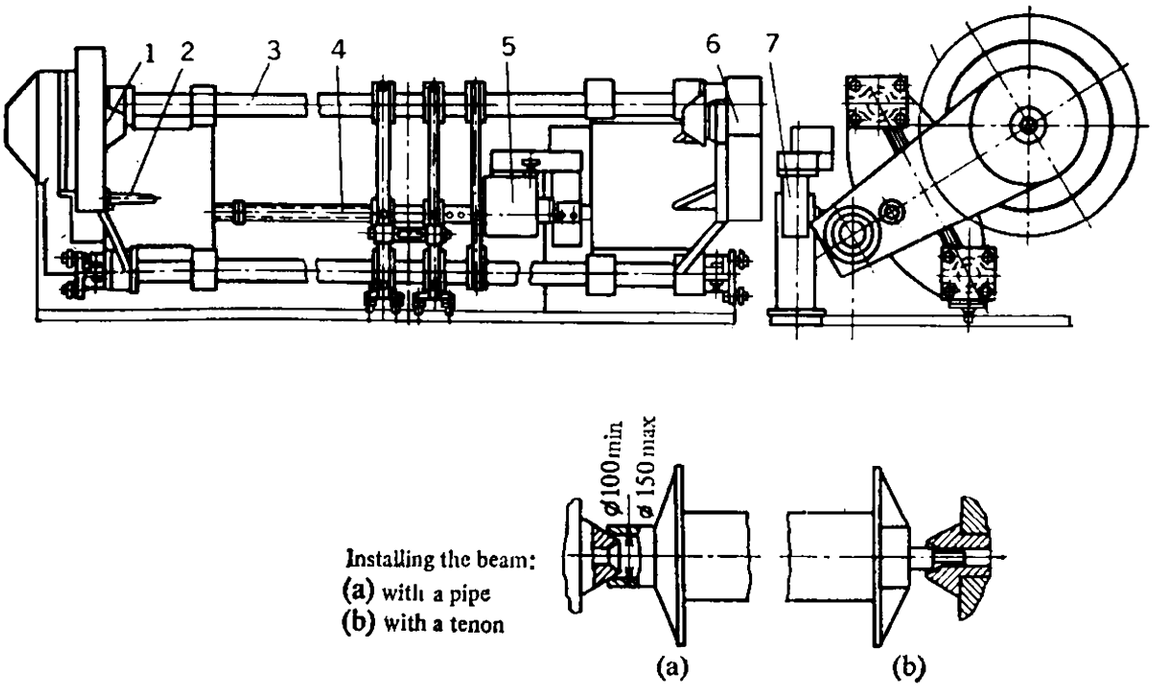


Fig 115. Weaver's beam setting mechanism

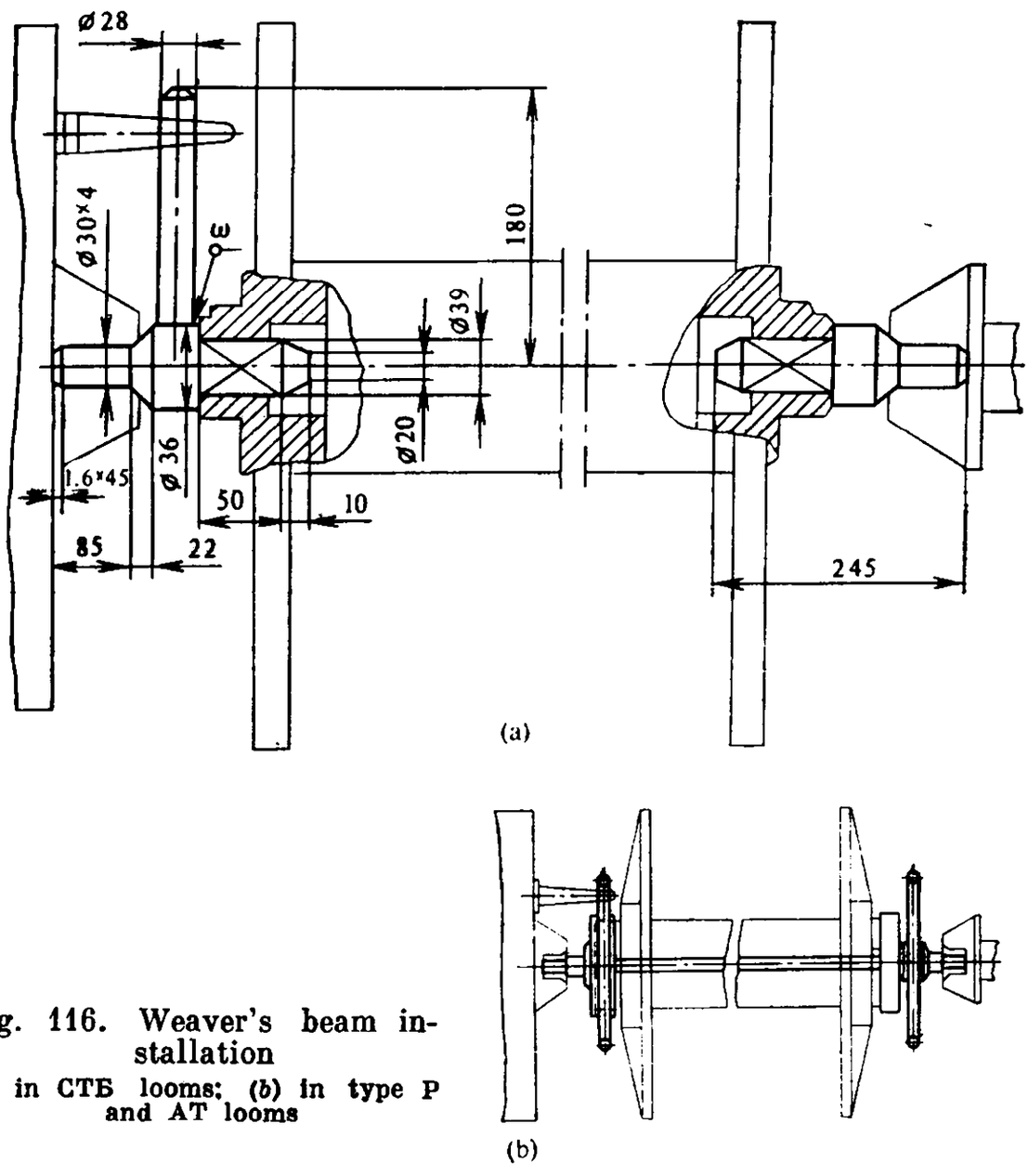


Fig. 116. Weaver's beam installation

(*a*) in СТБ looms; (*b*) in type P and AT looms

the smoothening roller and the mechanisms for setting and removing the weaver's beam.

The ribbed roller is made of a steel pipe and is provided with ribs of wooden planks which are attached to the roller periphery and form a ribbed contour. The roller is repaired by restoring the plank fixtures.

The delivery roll (*welded*), 250 mm in diameter, is made of a steel pipe with rubber coating. Provided on the delivery roll pin is an overrunning clutch which in weaver's beam replacement impedes the slackening of warp tension in the zone: drying cylinders—delivery roll. When repairing the delivery roll the worn-out coating is replaced and the overrunning clutch is restored or replaced.

The smoothening roller arranged before the weaver's beam reciprocates for shifting the layers of warp wound on the weaver's beam in respect to each other.

The weaver's beam setting mechanism (Fig. 115) consists of two guides *3* mounted on the framework of the delivery section along which the right-hand tail spindle *1* and left-hand tail spindle *6* are moving; the driving shaft with chuck plate *2* for rotating the weaver's beam; the mechanism for centring the weaver's beam; and the mechanism for displacing the tail spindles. The weaver's beam centring mechanism has a reverse box *5*, a mechanism controlling the lead screw reverse box *4*, the worm reducer *7* and the motor. The mechanism for tail spindle displacement consists of the same units as the centring mechanism, but in addition it is provided with a coupling

Table 10. Disarrangements Most Frequently Encountered in Cylinder Sizing Machines

Description of faults	Causes	Methods of elimination
Insufficient squeezing of warp by squeezing rolls. Warp coming from squeezing rolls is slashed and not properly squeezed	Rubber membrane in pneumatic chamber is broken. Air leakage in supply line. Irregular surface of rubber coating on squeezing roll	Replace the membrane using soap water, check the line of air supply to pneumatic chamber. Turn the roll or replace it with a new one
Solution in tank is not heated or heats up during more than 20 min. Steam supply line and electromagnetic valve are in good order. Engagement of by-pass line gives no result	There is not enough glycerin in tank's interbottom space. There is air cushion between glycerin and tank wall	Fill the tank's interbottom space with glycerin
Steam leakage in sylphon butt face seal on drying cylinder	Adherence of butt face packing ring is impaired	Tighting the spring and wipe the ring

for limiting the effort of the tail spindles when installed. Figure 116 illustrates different methods of mounting various types of weaver's beams.

The weaver's beam removal mechanism consists of two similar units comprising a jack which may be shifted in vertical and horizontal directions. The most frequently encountered disarrangements in cylinder sizing machines are listed in Table 10.

Adjustment and Lubrication of Sizing Machines

After the repairs and assembly of the machine it is put in idle running. Prior to starting the machine it is necessary: to ascertain that all the parts are in place and properly fixed; to fill oil in the reducer and variators and to lubricate the bearings, gears, chain drives and all rubbing parts; to check for easy rotation the transfer, measuring, pressure and smoothening rollers, and also the adjusting handwheels of the reed mechanism; to check the operation of pneumatic devices: the membranes of the top squeezing roll, the weaver's beam removal mechanism, the pressure roller (when compressed air is let in, its pressure should not exceed 0.4 MPa) as well as the mechanisms for lifting the immersion roller, the mechanism for displacing the weaver's beam setting brackets and so on; to take away all unnecessary articles and tools so that they do not get inside the machine working organs; to check the proper engagement of motors and push-button stations. This done, the machine is started for slow running and further for running at working speed. At the same time it is necessary to ascertain that the interlocking devices operate in due time and that the machine smoothly passes from slow to working speed and vice versa. For checking, compressed air is supplied into the pneumatic chambers of executive mechanisms. Simultaneously checks are done for air leakage in the connections; it is necessary to make sure of easy rotation of transfer rollers, drawing, squeezing and delivery rolls, cylinders, immersion rollers, and the adjusting handles of the reed mechanism, etc. All the defects detected during machine inspection at idle running should immediately be eliminated.

After all disarrangements have been eliminated, the machine is ready for running. The tank (trough) is filled to the required level with a size solution and steam is supplied in the interbottom space of the tank (trough); if necessary live steam is fed into the coil for heating the solution to the preset temperature. Prior to feeding steam into the driving cylinders they are blowed, the filters and condensate eliminators are checked and cleaned from contamination; supplied from a separate compressor or from the mill centralized system compressed air is fed into the systems for controlling the machine mechanisms; the automatic regulators are adjusted for

the preset temperature and for a certain level of the size solution according to the instructions supplied with the instruments and to the adopted sizing routines. After sounding a warning the machine is started for slow speed running.

The further adjustment of the machine is done at working speed. After starting the machine for running at working speed it is necessary:

1. To adjust the warp tension: between the drawing and squeezing rolls by adjusting the drawing roll; between the squeezing rolls and big cylinder by adjusting the back equalizing mechanism; between the drying cylinders and delivery roll by adjusting the front equalizing mechanism or by winding a bunch on the delivery roll; between the delivery roll and weaver's beam by modifying the tension of braking belts or by means of the movable friction weights. Moreover, it is necessary to adjust the stretch of warp yarns in accordance with the adopted technological conditions of the sizing process. Special attention should be paid to the tension of moist warp.

2. To check the amount and regularity of squeezing and the density of warp winding on the weaver's beam. If squeezing and winding density are insufficient it is necessary to increase the air pressure in the corresponding pneumatic chambers.

Table 11. Lubrication Chart of a Cylinder Sizing Machine

Mechanism	Lubricant	Method of lubrication	Periodicity of lubrication
Drying cylinder bearing	Universal grease	Cap oiler	Once a week
Antifriction bearings of transfer rollers, shafts, and drive units	Universal grease	Grease gun, cap oiler	Every 30 shifts
Open gearings, chain drives	Universal grease Graphite lubricant	Wooden spade	Once a week
Sliding points of hinge axles, rods pneumatic cylinders	Industrial oil	Hand oiler	Once a week
Chain drive of tail spindle	Universal grease	Grease gun	Once a week
Reducers	Industrial oil	Fill in oil according to indicator in the frame	Adding oil once a month
Lead screws, guides	Industrial oil	Hand oiler	For the first time with the lapse of 200 h, and further every 1000 h of operation
Equalizing mechanisms	Industrial oil	Filling in oil according to indicator in the frame	

3. To open completely the slide valve of the exhaust ventilation when establishing the adequate conditions for warp drying. Further adjustment should be carried out according to the drying conditions and parameters of exhausted air.

4. During the time when the operation speed is established the humidity regulator must be disengaged. The speed of warp motion depending on its humidity at the exit from the drier must be modified manually from the control board. The machine may be set on automatic humidity adjustment only after it has been running at a relatively constant speed.

5. The length of the fabric piece must be preset on the programme counter for making the mark on the warp after the adjustment has been completed. All observed disarrangements in machine operation must immediately be eliminated.

Scheduled preventive (medium) repairs of sizing machines should be carried out once in six months and the overhaul repair once in three years. The machine is lubricated according to a special schedule established by the manufacturer (Table 11).

REVIEW QUESTIONS

1. What kinds of sizing machines do you know?
2. What are the operations carried out at medium and overhaul repairs of sizing machines?
3. Discuss the main disarrangements of sizing machines and the methods of their elimination.
4. How is the size tank repaired?
5. What repair methods of squeezing rolls do you know?
6. Discuss the purpose and arrangement of drying cylinders.
7. How is the weaver's beam installed in a sizing machine?

3. Looms

Classification of Looms and Kinds of Their Repairs

The loom mechanisms may be classified according to their application into three groups: (1) the main working mechanisms for the execution of the principal technological operations in the process of fabric formation (shedding and weft insertion motions, slay, fabric drawing-off and winding mechanisms, warp tensioning and releasing arrangements); (2) complementary working mechanisms taking no direct part in the process of fabric formation and mounted on the loom mainly for increasing its efficiency (the weft feeding mechanism); (3) safety mechanisms effecting control over loom operation, precluding fabric faults in case of disarrangements, and

protecting loom parts from breakage (warp and weft controllers, warp protection motion, etc.).

Classification of looms. Looms are classified by the method of weft insertion in the shed and the method of fabric formation on the loom.

According to the method of weft insertion in the shed, the looms are grouped into shuttle and shuttleless looms (AT)*. In their turn the shuttleless looms are subdivided into looms with small weft inserters (type СТБ)**, pneumatic looms (type P) and hydraulic looms (type H)***, rapier and pneumatic rapier looms (type АТПР)****. In shuttle looms the weft yarn is laid in the shed by a shuttle carrying a bobbin with a reserve of weft yarn. Unlike the shuttle looms, shuttleless looms effect weft laying by weft inserters (small size inserters, by water or air jet and by rapiers) which carry no reserve of weft yarn. In this case the weft yarn is unwound from big stationary packages disposed outside the shed.

According to the method of fabric formation the looms are subdivided in two types: looms with an intermittent frontal (over the whole width of the warp) fabric formation (shuttle and shuttleless looms in which beating-up of the weft yarn is effected by the reed simultaneously over the whole width of the warp); and looms with continuous fabric formation (flat and circular multi-shed looms in which the weft yarn is laid by the inserters in the sheds consecutively formed along the width of the warp; beating-up of the weft yarn is effected by special devices simultaneously at several points of the warp width correspondingly to the number of weft inserters moving in sheds).

The design features of the looms are determined by the kind of raw materials, the end use of the fabric and the design of loom's individual mechanisms. At present the following kinds of looms are manufactured: for the production of cotton, woollen, silk and linen fabrics, as well as fabrics of glass yarns and wire meshes, for the production of light, medium and heavy, narrow and wide fabrics; single shuttle and multishuttle looms, tappet, dobby and Jacquard looms, including versatile looms. So for instance, shuttleless looms of the СТБ type are successfully employed for manufacturing fabrics of man-made, silk, cotton, and woollen yarns of different linear density. These looms may be used for manufacturing not only narrow fabrics in several webs but also wide fabrics in one and two webs. The automatic rapier looms type АТПР with weft insertion by pneumatic

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* АТ—automatic shuttle loom.

** СТБ—shuttleless looms.

*** Pneumatic (P) and hydraulic (H) looms (manufactured in CSSR) are mainly of similar design, and therefore, only pneumatic looms are discussed in the present manual as they are most widely used in the textile industry.

**** АТПР—automatic rapier looms.

rapiers and the pneumatic looms of the type P with pneumatic weft insertion are intended for the manufacture of cotton and silk fabrics.

Kinds of loom repairs. The looms are subjected to current, preventive maintenance, medium, and overhaul repairs.

Current repairs are carried out by the assistant foreman and come to the elimination of disarrangements and certain failures of parts in the course of operation.

Preventive maintenance repairs are carried out also by the assistant foreman which establishes every day a schedule for the inspection and repair of the looms in his charge so as to preclude any disarrangements in the looms and part breakage.

During current and preventive repairs, complementary and small parts are replaced, the parts and mechanisms are checked for fastening, adjustment, and interaction. The following points are checked: the fixing of the loom stand to the floor and the reliability of bolt connections; the easy starting of the loom, the proper adherence of braking blocks to the braking pulley, the smooth stoppage of the loom in closed shed position; the tension of V-belts transmitting motion from the motor to the pulleys; the clearances in bevel gears; the oil level in the boxes of the rapier drive as well as in the systems ensuring oil feed to different parts and mechanisms of the loom; the position of the rapiers with respect to their guides and clearance between the rapier cover plates and the reed; the operation of the conveyor and the proper condition of the weft inserter tips; the tightness of the torsion shaft and beginning of picking; the setting of weft inserters and the operation of their brakes; the work of the loom brake and the degree of braking; the pressure of the weft inserter lifter in top and bottom positions; the pressure of the lever of the weft feeder in top and bottom positions; clearance between the picker and the butt face of the weft inserter; the regular feed of warp and fabric rolling-up; the operation of the selvedge binder mechanism; the proper installation and operation of the nozzle; the faultless work of the weft brake; the proper installation of the scissors and the quality of weft yarn trimming; the correct installation of the fabric fell controller in respect to the fabric fell and the amount of fabric drawing-up; the reliable fixing of the warp stop motion in the seat and the plugs of the dropper stop motion; the mounting and operation of temples; the amount of binder loop tucking-in; the proper operation of the leno device; the operation of the fluff exhaust; the tension of the cloth between the cloth roller and take-up roller; the operation of rapiers, nozzles and inserters (check that they are not clogged with fluff); the correct motion of rapiers and inserters in the shed; the position of the confuser. All the observed disarrangements are to be immediately eliminated.

The medium repairs are carried out according to the schedule at least twice a year, and in case of the loom's heavy wear more fre-

quently. The medium repairs involve cleaning and checking the loom with the partial dismantling of main units, and the replacement or restoration of some badly worn-out parts which cannot ensure loom normal operation. The time assigned for medium repairs is usually not more than one shift. The repairs are carried out by a team of two workers.

The overhaul is carried out once in two or three years by a team of workers. In overhauling, the loom is completely disassembled, the worn-out parts are replaced and the units are checked and cleaned. After the overhaul, the loom technical condition slightly differs from a new one. If after the overhaul some old parts are left for further use, these parts must be restored to good technical condition and a special statement should be made in the reception certificate. The volume of work to be performed during medium repairs and general overhaul of looms is determined in special instructions.

The foreman of the mechanical repair department stops the equipment for medium and general overhaul repairs at the dates called for by the repair schedule. Before submitting the looms to repairs, they must be cleaned and the gaited warp removed.

Repair and Adjustment of Parts, Units and Mechanisms

Frames, Braces and Breast Beam

The frames, braces and breast beam when assembled together form the loom framework. Usually they are cast of iron or steel. To ensure the adequate rigidity and stability of the framework, the frames and braces are provided with reinforcement ribs along the whole contour, thus forming a trough or double-Tee section.

In the course of loom operation cracks, cuts, worn-out holes for shafts, inserts, etc. may be observed and breakages may occur. Cracked and broken frames are repaired by welding or by machining. The welding method depends on the place of cracks and chipping. If they are disposed at sharp curvatures in the frame profile, hot electric arc welding (with preliminary heating) is used; while in all other places it is advisable to use cold welding.

In *hot welding* the places to be repaired are cleaned from dirt and oil, the crack is made up as an Y-shaped seam and at its sides graphite plates are fixed in place with fire clay to protect melted cast iron from spreading about. The frame prepared in this way is subjected to local heating to 600-650°C using a gas burner. The heated points are closed with an asbestos sheet and the cracks are welded after which the frame is slowly cooled and the seams finished.

In *cold welding* the points to be welded and the adjacent surface are cleaned from dirt and oil after which Y-shaped bevels at an

angle of 90° are cut, their depth being equal to 0.25-0.5 frame wall thickness. Broken parts are joined along the line of breakage. In each chamfer a row of holes is drilled and threaded for pins to be disposed in checkered order (the hole spacing of 25 to 30 mm, the depth of 1.5 wall thickness, and the diameter of 5 to 8 mm). The pins must be screwed to the end and protrude from 3 to 4 mm above the surface. To begin with the pins are welded with annular beads and then longitudinal beads are formed.

There are other methods of frame repairs, for instance a steel cover plate is cut and bolted or riveted to the frame with subsequent welding along the contour. The frame with a worn-out hole for the shaft is repaired by changing the hole size into the repair size or by press-fitting a repair bushing. In this case not only the corresponding size is to be maintained, but also the geometrical axes of the frame holes must coincide so that shaft misalignment is avoided. The hole size may be made of a repair size by turning and reaming in a drilling machine or by means of other devices. In the first case, the frames are removed and bolted together so as to bring in coincidence the holes for the shaft, after which depending on the amount of wear and the deterioration of the hole shape they must be reamed on the drill. Other methods may be also used by applying hand or motor-driven boring bars. Worn-out frame surfaces for the inserts of a crankshaft or any other shaft are filed, metal sprayed or built-up with brass after which they are machined to accommodate the inserts. A broken thread in a frame hole for a pressure bolt is cut to accommodate a bolt of greater diameter. Worn-out seats for the take-up roller journal are built-up by welding and carefully filed. Broken and cracked braces and the breast beam are mainly repaired by welding and reinforced by steel cover plates.

Drive

In СТБ *shuttleless looms* and the АТПР automatic rapier looms the braking force of the main shaft is adjusted by means of the bolt *7* (Fig. 117): to increase the main shaft braking the bolt is to be tightened and to reduce it the bolt must be loosened. Turning of the shaft by inertia at the moment of loom stoppage should not exceed 25°. For checking, the weft yarn is removed from the feeler of the weft controller and the main shaft is turned by hand—in this case the disengagement of all СТБ shuttleless looms must occur when the main shaft has turned over 255° (but not later than at 280°). To avoid rubbing of the exterior part of the braking flywheel *5* against the braking belt *6* at the moment of shaft rotation, it is necessary to adjust a clearance of 0.5 mm over the entire circumference of the braking flywheel between the braking belt and the flywheel. This clearance is adjusted by means of the bolts *3* provided in the station-

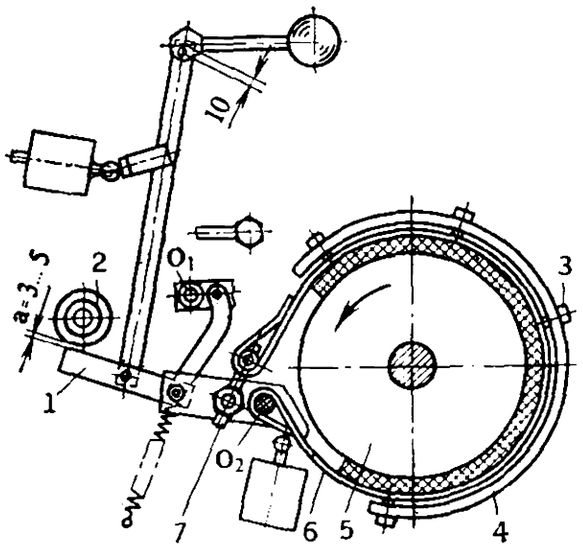

Fig. 117. Diagram of drive for types СТБ and АТПР looms

ary block *4*. The distance *a* between the lever *1* and the support roller *2* must be equal to from 3 to 5 mm (when the loom is engaged).

When mounting the braking strap (not shown in the drawing) intended to retain the flywheel against rotating during loom operation, its end must protrude (at the point of contact with the flywheel rim) by 6 to 7 mm from the rim and the side face of the flywheel should be from 3 to 4 mm away from the main shaft face. If the braking strap is not correctly installed, an excessive friction is created between the main shaft and the flywheel pedestal due to which it is excessively worn out. The distorted hole of the flywheel pedestal is turned and a new bushing is press-fitted into it. To increase the life of the bushing an annular groove and longitudinal lubrication canals are cut in its hole.

The irregular lubrication and excessive tension of V-shaped belts cause the wear of the pulley holes. The worn holes in the pulleys are restored as described above. V-shaped belts are tensioned by the motor mass. For this, the bolts fixing the motor on the loom frame are released and the belts are tensioned by the weight of the motor, after which the bolts are retightened.

In *shuttle looms* the wear of parts is caused by slackened fastenings in the course of the drive operation. Usually, the fixing of the small gear on the main shaft becomes slack due to the wear either in the gear keyway or in the key, to tight meshing of intermediate gears and the wear of drive gears toothing. For this reason when need occurs the gears should be turned on the shafts. The small gear is placed on a new keyway. For this, the guard hood and the friction clutch are removed, the burrs and dents on the main shaft are eliminated especially on the keyway, the key is driven out and the small gear is brought out of engagement with the big gear, the small gear is turned round with the new key hole upwards, brought in engagement with the big gear after which the key is inserted. The main and medium shafts should not turn in bearings so as not to impair the beginning of picking.

When the place of the big gear on the middle shaft is changed, it is necessary to remove the guards and the friction clutch, to bring the slay in position corresponding to the beginning of picking from the right side of the loom, to unscrew the nut for releasing the big gear

on the shaft and to bring it out of meshing with the small gear; next the big gear on the shaft is to be turned through several teeth, brought again in meshing with the small gear. Then the big gear is to be secured on the shaft with a bevel bushing by tightening the nut. Care should be taken that the middle shaft carrying the picking cam is not shifted from its place (as otherwise the beginning of picking will be impaired), and that the friction gear easily turns on the hub of the small gear.

When adjusting the friction clutch it is necessary to obtain the same force of pressure of all screws on the pressure disk (otherwise the pressure disk may be misaligned in respect to the thrust disk which will lead to an irregular running of the loom). The pressure of the screws is adjusted by slightly shifting them with a screwdriver in the holes of pressure pawls. If the loom operates for a long time, the unequal action of the screws on the lugs of the pressure disk causes the premature wear of the ferrodo rings at the points of strong pressure applied by one of the screws, so that the loom begins to "clatter". In this case, the ferrodo ring is to be replaced and the pressure screws should be properly adjusted. When the disks are slightly pressed, a strong noise is emitted in the friction clutch during loom operation and during the first weft laying the shuttle fails to fly in the box. When the disks are strongly compressed at the moment of loom starting the keys of the driving gears may be broken and the noise continues in the friction clutch after the loom is off. The working surfaces of the friction clutch disks are periodically cleaned with emery paper from dirt, fluff, and oil.

In high-speed pneumatic looms the drive parts are worn quicker than all the rest. Most often it proves necessary to replace the slotted shaft *1* (Fig. 118), the disk *2*, the key *6*, the rod *4*, the bearing *5* and the ring *3*. These parts may be easily restored by building-up the worn places by oxyacetylene welding with subsequent manual finishing or on a lathe. An exception to this are the slotted shaft *1* and disk *2* as on the shaft *1* usually the slots are worn out and it is easier to replace the shaft, rather than to restore the slots. The slots are also worn in the disk *2*, but they may be restored. For this a cut-out is made in the hub of the disk, a bushing is prepared and press-fitted inside with welding of edges followed by broaching the slots on a special machine. This kind of restoration is time-consuming operation and therefore it is resorted to very rarely.

In the starting arrangement replaced or restored most frequently are the following units: the trigger *3* (Fig. 119), the sector *4*, the shafts of the bearings of lever *6* and the starting crank pin. These parts may easily be restored by building-up with subsequent finishing. The springs *2* and *7* are very often broken and their replacement is labour and time consuming. These springs can be replaced by more simple devices. The bolt joining the cams *1* should carry a small

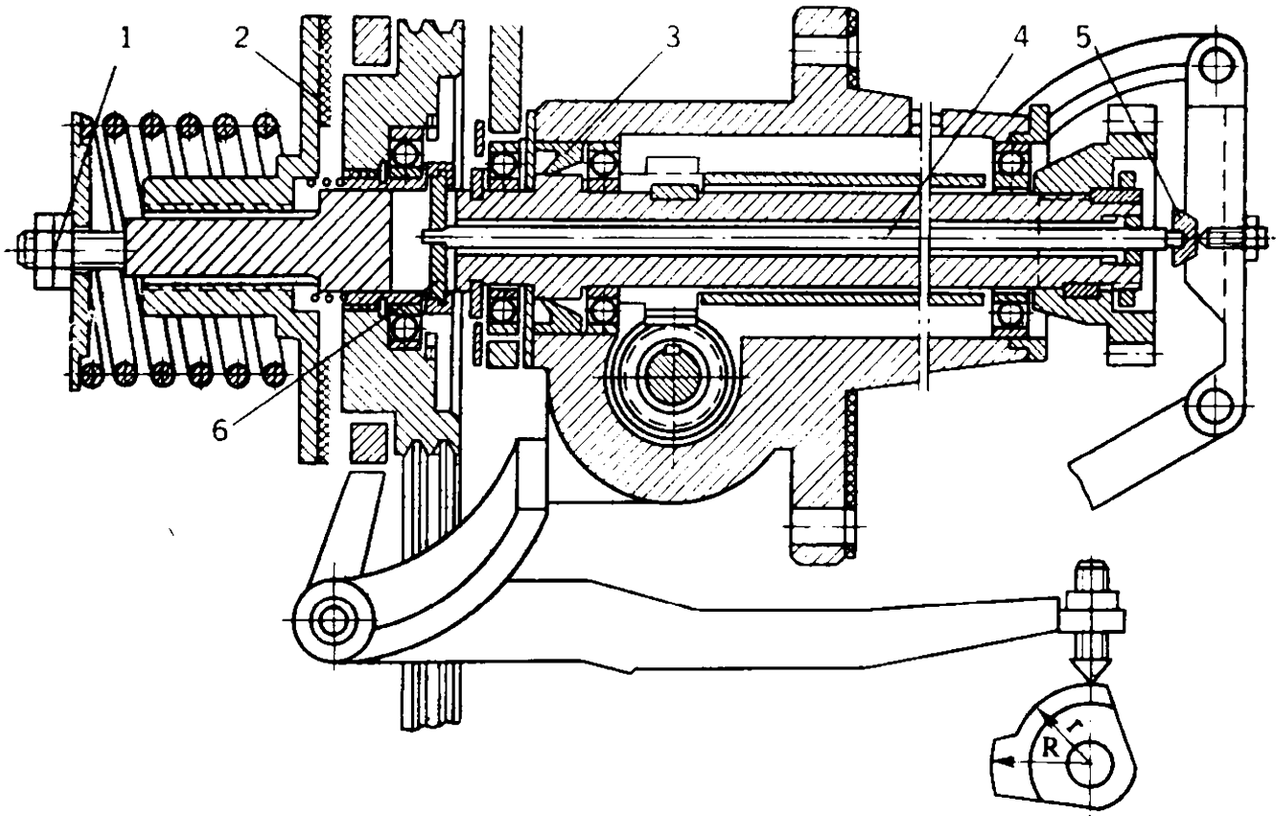

Fig. 118. Diagram of drive for type P loom

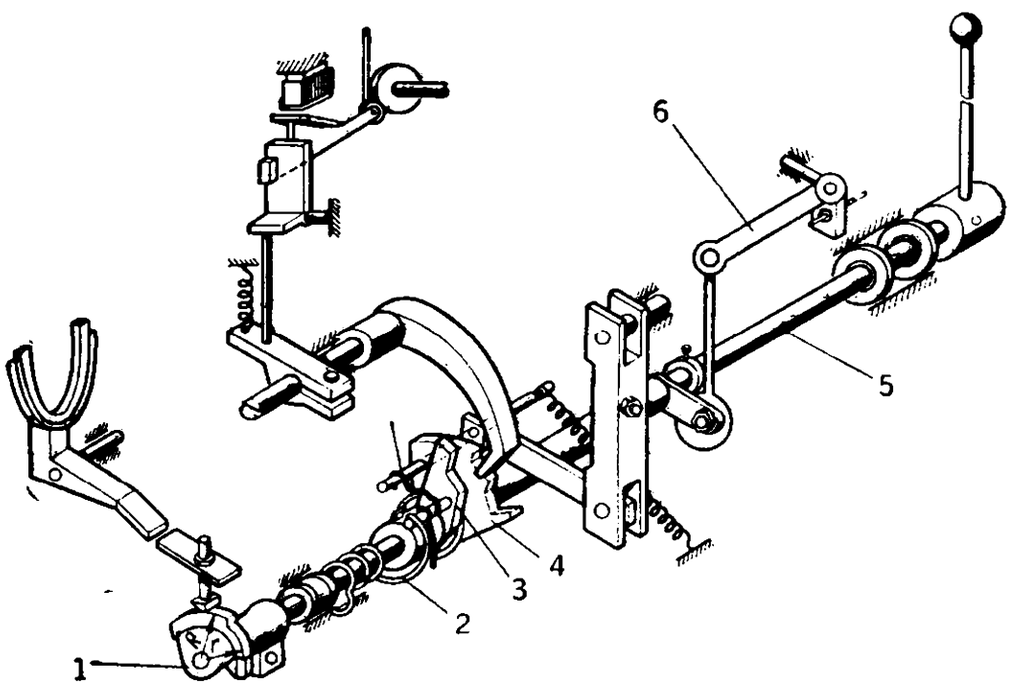

Fig. 119. Diagram of starting device in type P loom

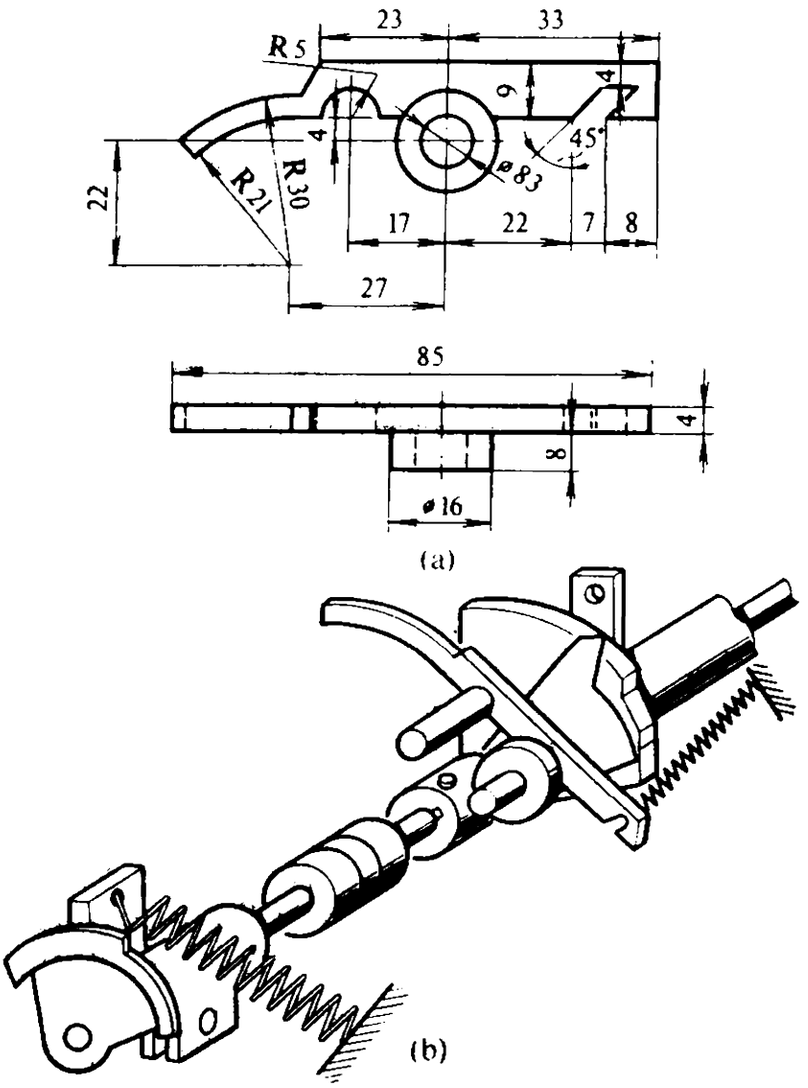

Fig. 120. Modernized starting device of type P loom

stand having a hole at the end and the end of a small helical spring is to be fastened to this hole, while the second end of the spring is to be fixed on the frame. This spring will replace the return spring *2*. It is convenient to adjust with it the tension, and what is more important it may easily be replaced. Instead of the humped spring *7* which is very inconvenient for replacement, a spring-loaded pawl may be used (Fig. 120*a*, *b*). The pawl is reliable in operation and may be replaced only with the lapse of several years. As the starting device is assembled, the roller *5* (see Fig. 119) should have no axial displacement and must easily rotate.

Shedding Motion

The following three types of shedding motions find application in modern looms: tappet motion, dobby, and Jacquard mechanism (Jacquard shedding motions are not discussed in this book).

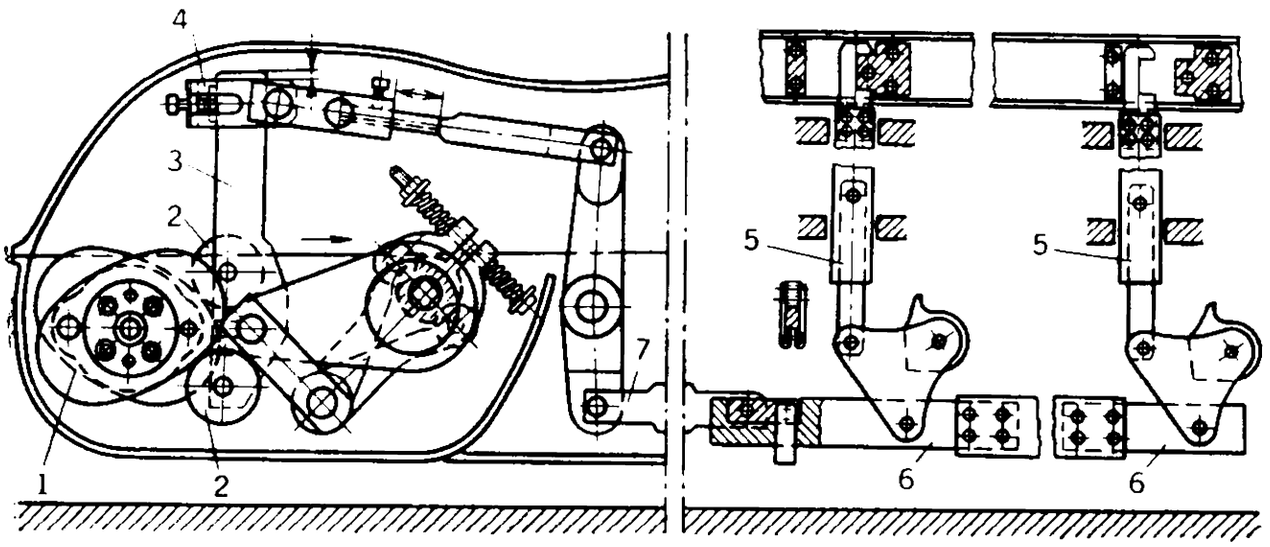

Fig. 121. Diagram of motion transmission to healds

Shedding motion of the СТБ shuttleless and АТПР automatic rapier looms. As the shedding motion is adjusted, the angle of shed opening, the shed height relative to the comb teeth and the moment of shed closure are adjusted. The angle of shed opening may be from 18 to 26° depending on the kind of processed raw materials. During loom erection this angle is adjusted to 21°, for which the shackles *4* (Fig. 121) on the heald levers *3* are displaced downwards over a distance of $a = 35$ mm. The shed angle decreases with the increase in the dimension *a* and vice versa. The shed height in relation to the slay comb teeth is adjusted by modifying the dimension *b* which is usually set equal to 10-15 mm.

Depending on the produced assortment of fabrics, the closed shed position is set when the main shaft turns from 0 to 20°. For adjusting the closed shed position, the bolts fixing the change sprocket are released and the heald frames are turned (using the bolt) in closed shed position (on one level), while the sprocket must remain stationary. After the closed shed position has been adjusted the sprocket is bolted. The clearances in the articulated joints of horizontal drawbars *7* and rods *6* are eliminated by replacing bushings or rollers. If the holes in the guide plates *5* are worn-out, the distorted part is cut-away and a metal plate of corresponding thickness is fitted into the hole and welded into the guide plate. This done, the welded points are finished, and the holes are drilled to the size indicated in the drawings. To eliminate the clearances between the rollers *2* and the shedding tappets *1* it is necessary to replace the worn-out parts in this point of the mechanism. If after the replacement of worn-out parts the clearances are not eliminated, the bushing in the levers *3* are replaced by accentric bushings. Prior to making such bushings, the clearance between the rollers and tappets must be measured. At the moment of measuring, the bottom roller must be

pressed to surface of the counter tappet. The obtained size of the clearance is divided by two and the hole in the newly manufactured bushing is shifted over the obtained dimension. The ready bushing is press-fitted in the lever so that its hole is shifted to the right.

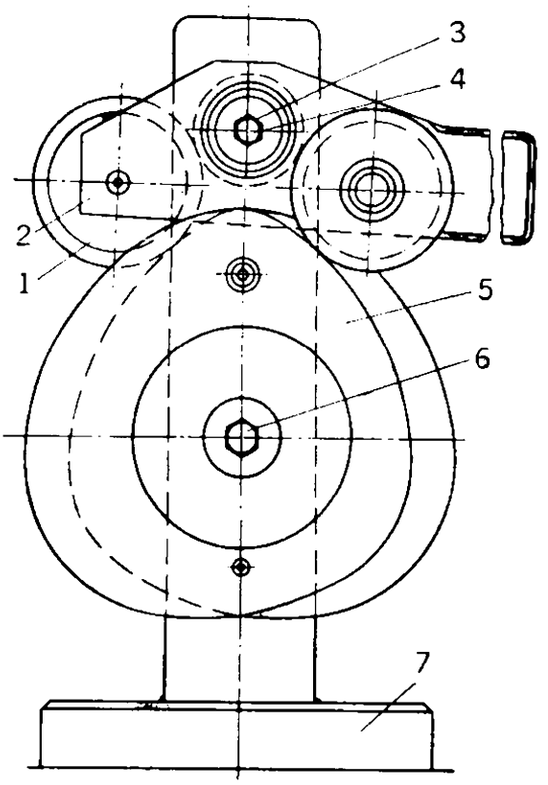

Fig. 122. Diagram of device for imparting tappet required dimensions

The worn parts of the tappet surfaces are restored by building-up. For obtaining the tappet of required dimensions a special device is used consisting of the stand *7* (Fig. 122) with two shafts *6* and *4*. The top shaft *4* may be displaced in vertical direction in the stand slot and fixed with the nut *3*. For checking, the tappet *5* is fitted on the shaft *6* and the heald lever *2* on the shaft *4*. Next, the shaft *4* is lowered until the roller *1* contacts the surface of the tappet *5* and fixed with the nut *3*; the tappets are turned over a full revolution on the shaft *6* in order to find the wear which would be restored by building-up with welding. Further, the excessive layers of metal are removed and the restored parts are gradually brought to required dimensions. After the tappet has been finished the rollers must easily run on its surface.

To avoid oil leakage through the glands of the tappet pipe shaft it is necessary to raise the gland above the surface of the shaft *6* as the leakage is caused by the excessively deep annular groove under the gland. The gland is raised by inserting a rubber ring in the groove. The gland surface should protrude 0.4-0.6 mm above the roller surface. The sharp edges of the gland groove must be rounded by filing.

A tappet shedding motion with rigid heald displacement finds application in pneumatic looms. In this motion it is necessary to replace the shaft *5* (Fig. 123) and spring protectors *1* more frequently than in other mechanisms. In the course of every two or three years of operation, the bottom drive shaft *4* causes heavy wear of the seat in the frame *3*, so that the frame *3* must be restored or replaced. When repairing the frame, the seat is bored to a greater size, a bushing is made with all the necessary slots and after press-fitting in the frame it is locked in place. After dismantling, washing and replacing the worn-out parts, the tappet motion is assembled taking

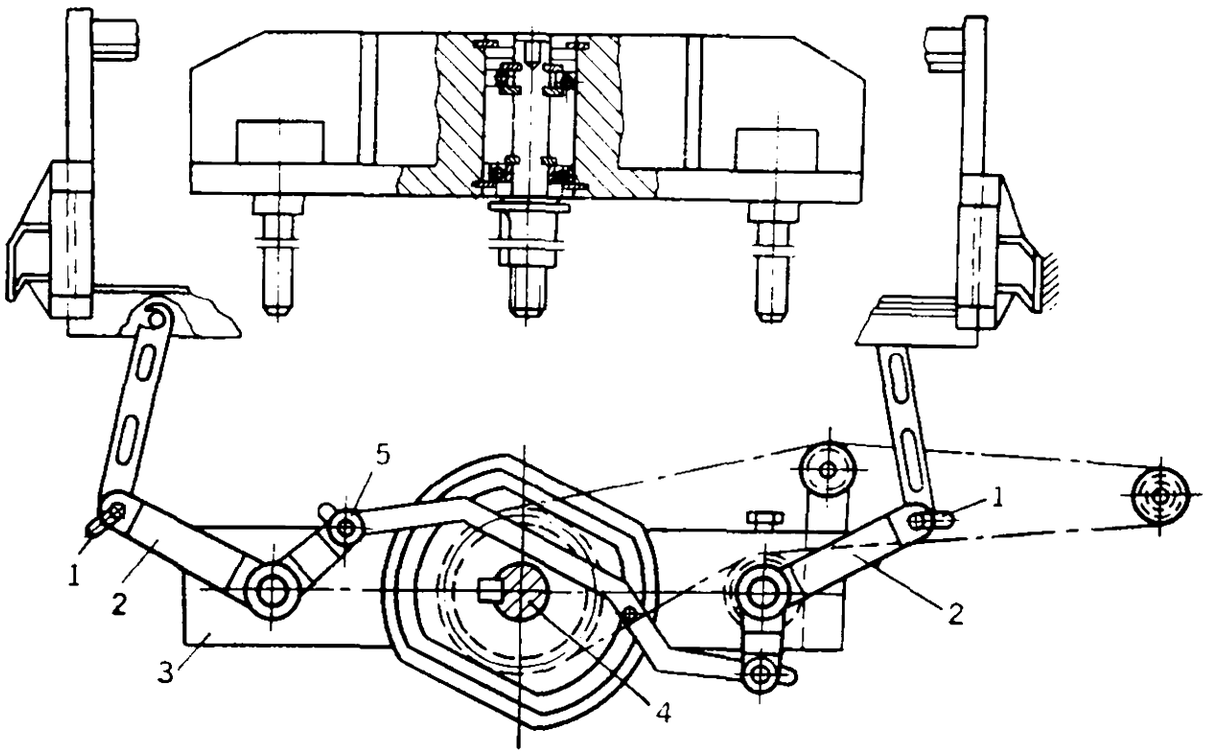

Fig. 123. Diagram of shedding motion of type P loom

care that the levers *2* do not contact each other in their movement, that there is no swinging on the shafts *4* and that the levers are on the same level. Prefabricated metal shafts *5* are rapidly worn-out and may be replaced by capron ones of the appropriate shape.

In the course of operation, the surface of the tappet is worn and cracks may appear. The distortion of the tappet contour brings changes in the law of heald displacement which may result in defectuous fabric. The worn surface of tappets are repaired by building-up with an allowance of 2 to 3 mm for further machining. First, after building up, the tappet surface is machined by grinding wheel and then finished according to a template on a lathe. As a template, is employed an accurately machined new tappet having a rim which is 3 or 4 mm greater than that of the repaired tappet (for cutter overrunning). The tappet to be repaired is imparted the same profile as the template. In turning, an allowance of 0.15-0.2 mm is provided for subsequent grinding on the lathe. The tappet profile is checked by means of a gauge. After preliminary local heating, the cracks in the tappet rim are welded. If spare tappets are available they are used to replace the worn-out tappets.

Dobbies. Most largely used in the textile industry are knife dobbies which being of different designs are similar in their principle of operation. The most typical are PK-12-1 dobbies for twelve healds used in shuttle looms and new type CKH dobbies with 14 to 18 healds

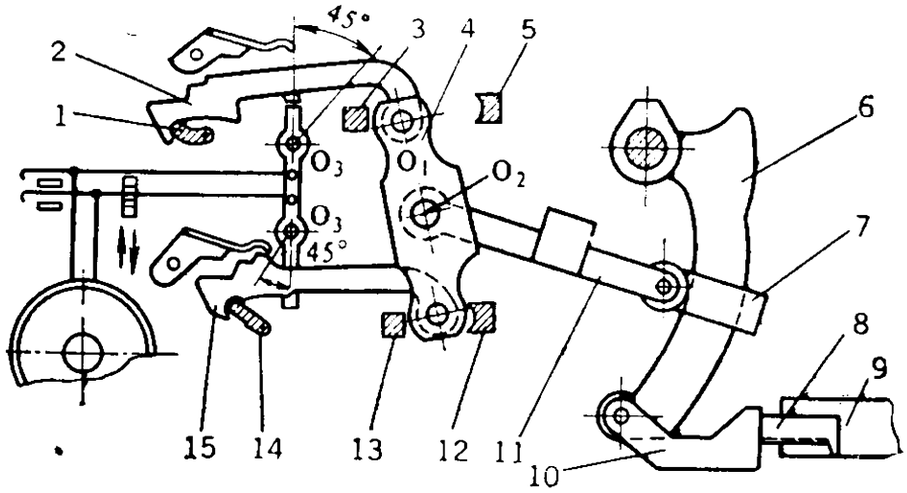

Fig. 124. Diagram of heald driving mechanism in CKH dobby

for the СТБ shuttleless looms*. The dobbies of both types relate to double-lift dobbies (the dobby operation cycle is effected during two revolutions of the loom main shaft).

The high-speed CKH dobby consists of the following main parts and mechanisms: the frame, the drive, the heald driving mechanism, the knives turning mechanism and the programming mechanism. The main mechanism is the heald driving mechanism with jacks *2* and *15* (Fig. 124), the balks *4*, the stationary rests *5* and *12*, the movable rods *3* and *13*, and leverage system *6-10*. In accordance with the pattern design the jacks *2* of the top row or jacks *15* of the bottom row are set on the line of action of knives *1* and *14*. The moving knife catches the jack and displaces it together with the balk *4*. The middle part O_2 of the balk on its displacement shifts the heald through the intermediate of the carrier *11*, shackle *7*, rocker *6*, lever *10*, the latch *8* and the horizontal drawbar *9*.

In dobbies the following parts come out of order the most: the jack rods, balks, jacks, knives, and sliders in the grooves of driving gears.

The *jack rods* are intended for transmitting the motion to the healds. In the course of operation their pins and forks, sometimes also the flats, are worn. The pin is worn by rubbing against a jack or balk, the fork by rubbing against the shaft and the flats due to the mutual rubbing of jack rods. Jack rods are repaired by different methods depending on their design. For instance, worn pins are drilled out or cut away on a milling machine. Further, holes are drilled and counterbored in the jack rods and new pins are inserted in the holes. New pins are welded from the side of counterboring and the

* The dobby CKH is available in the following executions: CKH-14—for 14 healds, CKH-14A—for 14 healds with drive to the colour change motion, CKH-18—for 18 healds and CKH-18A—for 18 healds with drive to the colour change motion. CKH—high-speed dobby of the double lift type.

weld is carefully ground on a grinding wheel. According to another method of jack rod repairing the worn pin is cut off by means of a disk milling cutter, and a hole is drilled in its place for a rivet which is countersunk from both sides. Next, a steel washer is cut out and fixed in the jack rod jaws with a rivet or by welding a steel rod. The worn jack rod fork is built-up and manually finished to suit the shaft.

The worn-out hole in the jack rod is drilled, reamed and a cast iron repair bushing is press-fitted inside. The worn-out flats are ground on a surface grinder and during assembly washers are inserted between them, the thickness of which is equal to the double thickness of the flat.

The *balks* are liable to develop the following faults in the course of operation: the holes and pins are worn-out and the eyelets broken. The worn-out holes are drilled, reamed, and bushings are press-fitted inside them. Worn-out pins are built-up and filed. In other cases the worn-out pins are cut off on a milling cutter. In the place of the cut-off pin through-holes are drilled in which steel washers are riveted or steel rods are welded. Damaged eyelets are cut off and in their place new ones are welded or soldered after which holes are drilled and finished in the eyelets.

The *knives* are liable to wear on the following places: the working surface of the shafts on which the jacks are operating, places on which knives rest on the frame guiding slots, and the ends to which the drawbars and draw jacks are attached. The worn-out working surface of the knife is built up and ground on an emery wheel and finished in a special device on a surface grinder in cross direction. The points where the knife rests on the frame guiding slots are built-up with cast iron. The built-up surface is worked to suit the slots and to ensure the easy displacement of the knives inside them. The worn-out ends of the knife are built up, ground and holes are drilled for cotter pins. In the course of operation the ends of *jacks* get worn or broken. The jack worn ends are built up and then carefully machined for proper fitting. Broken ends are welded.

In the course of operation the *capron sliders* in the slots of the driving gear in the CKH-14 dobby become worn and gaps are formed. As a result, there may occur wedging and consequently the breakage of mating parts. As the lubrication of sliders is difficult, it is good practice to make the sliders of a textile based laminate with oil impregnation (by keeping in an oil bath for 4-5 days).

For the repair, adjustment and running-in of the dobby a special stand has been designed. It is a rigid structure made of steel angles and channel with a motor from which the motion is transmitted through chain drive to the dobby shaft. The dobby is fixed in channel recesses on the stand. During running-in, the rotational speed of the dobby shaft is somewhat reduced to 160-180 min^{-1}. The running-in

of the dobby is effected during 2-3 shifts. The dobby is transported in the weaving shed and from the shed to the shops by means of a special car (Fig. 125) in which the dobby is suspended.

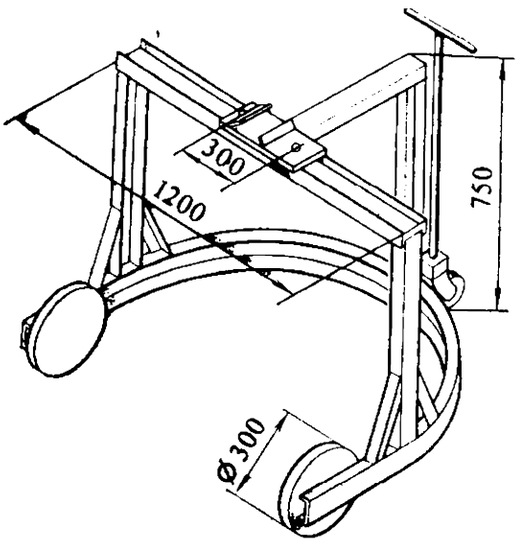

Fig. 125. Car for dobby transport

The lubrication charts for dobbies must be carefully followed. For each type of dobby special routines of lubrication have been established, but they are constantly modified and improved. For example, the driving gear rotating in two middle bearings must be oil lubricated once per shift. However, lubrication of the same gear with cup grease and the provision of a special oiler on the shaft allows lubrication to be made once every six months.

Weft Laying Mechanism

Picking box of the СТБ shuttleless loom. The tension of the spring *3* (Fig. 126) of the braking plate *1* should be such that the distance *a* when the adjusting bolt *4* is properly tightened is equal to 3, 5, and 8 mm for processing weft yarns of low, medium, and high linear density, correspondingly. When the loom main shaft is turned through 255° (for narrow and wide looms), the adjusting bolt *7* is unscrewed to the end and the braking foot *2* is set (with the nut of bolt *6* released) so that it makes a depression of 1-3 mm on the braking plate (the thicker is the weft yarn, the deeper must be the plate depressed). When the main shaft turns through 320° (for narrow and large looms) the adjusting bolt *7* is unscrewed until the foot depresses the braking plate by 2-4 mm. The final adjustment is effected by modifying the position of the foot *2* in relation to the height of the adjusting nut *5*. The compensating lever *1* (Fig. 127) when in bottom position must be 3-8 mm above the line of weft displacement. This position is adjusted by means of bolts attaching the compensating lever to the lever *2*.

Most frequently encountered defects in weft inserters are cracks in the frame causing the shift of spring grippers and tip wear causing the unsteady fixing of the weft inserter in the receiving box. When the weft inserter spring comes out of order it is replaced by means of a special device consisting of a steel plate with the groove *1* (Fig. 128) accommodating the weft inserter. The holes *4* of a diameter, which is by 1 mm greater than the diameter of the weft in-

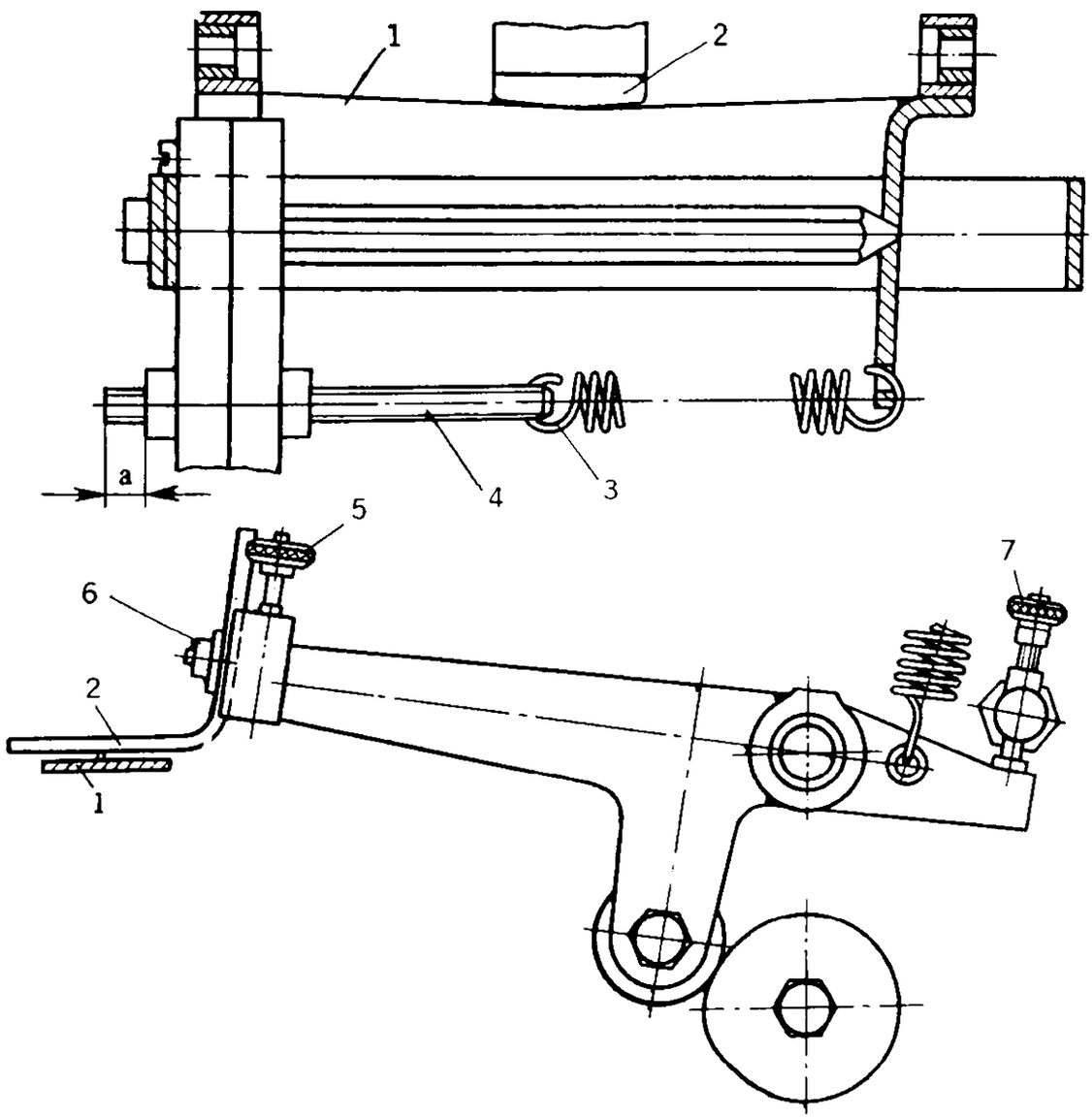

Fig. 126. Diagram of weft yarn compensator in СТБ loom

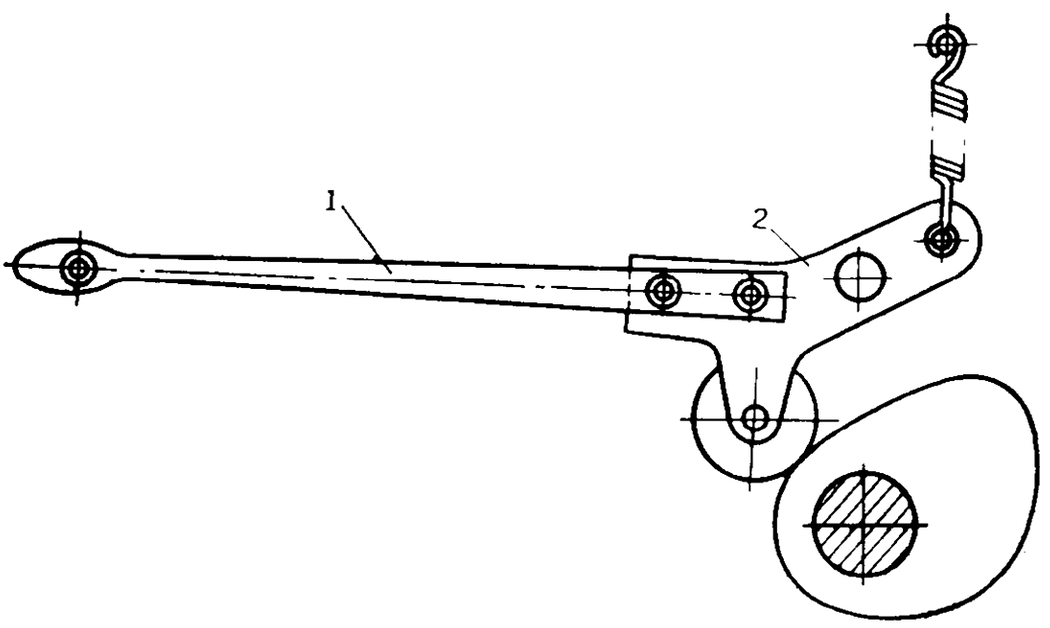

Fig. 127. Diagram of weft yarn brake in СТБ loom

serter spring rivets, are disposed opposite the holes in the weft inserter frame. Prior to the insertion of a new spring in the weft inserter frame, it is necessary to check the coaxiality of the holes *4* with the gripper jaws according to the match mark on the control pins *3*. Peening of tubular rivets is done by means of three cones with angles of 60, 90 and 120° and the protruding rivets are to be filed in longitudinal direction with subsequent sand-papering. If there appears a gap between the gripper jaws of the weft inserter spring, they must be lapped with paste.

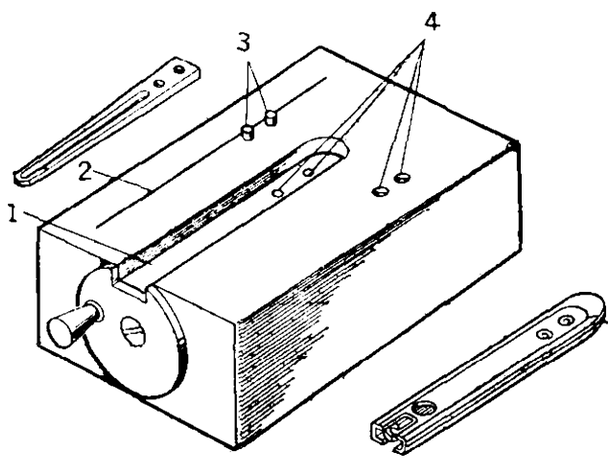

Fig. 128. Device for replacing weft inserter spring

Picking motion of СТБ shuttleless loom. The picking force of the motion is determined by the potential energy of the wound-up

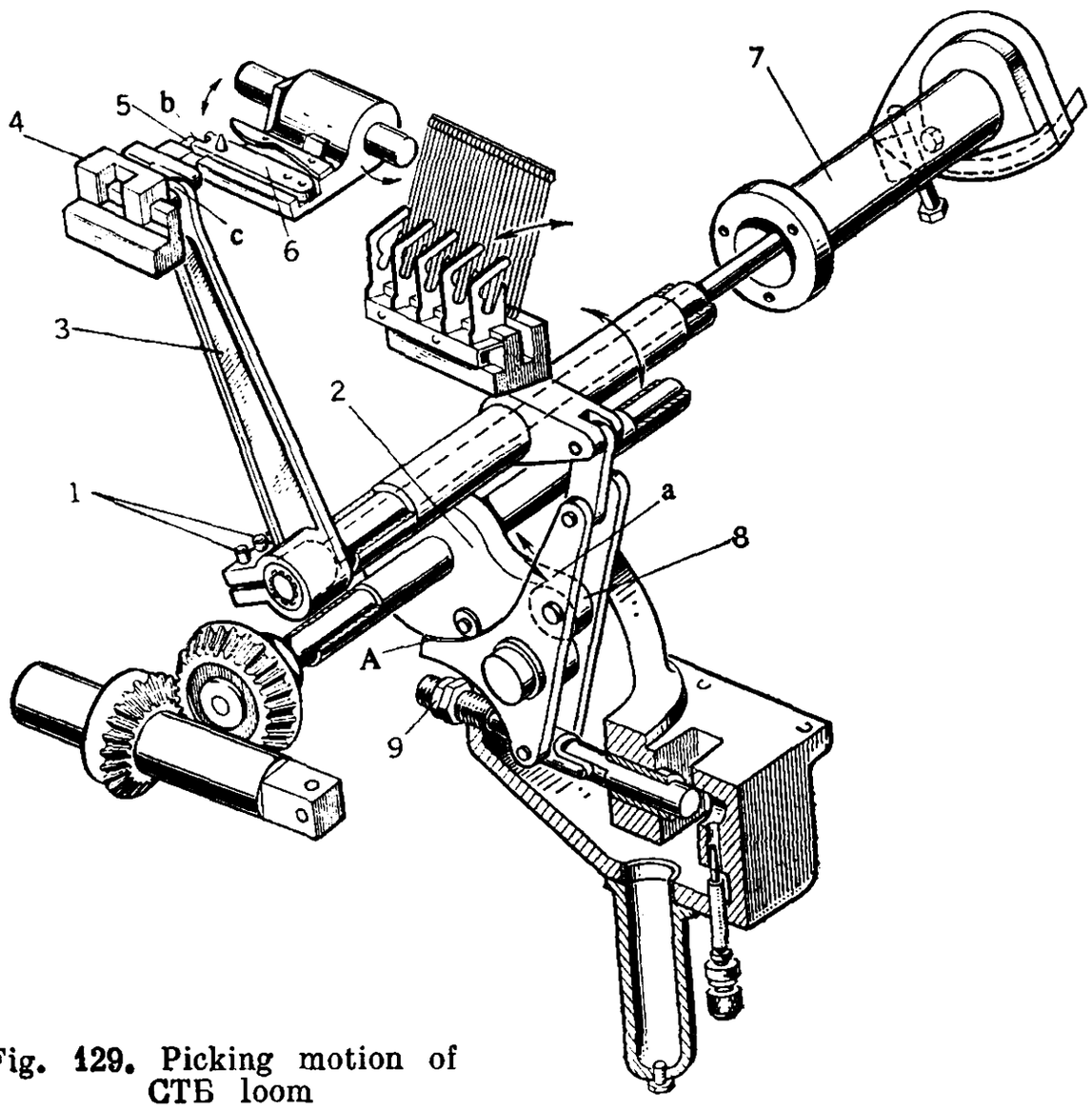

Fig. 129. Picking motion of СТБ loom

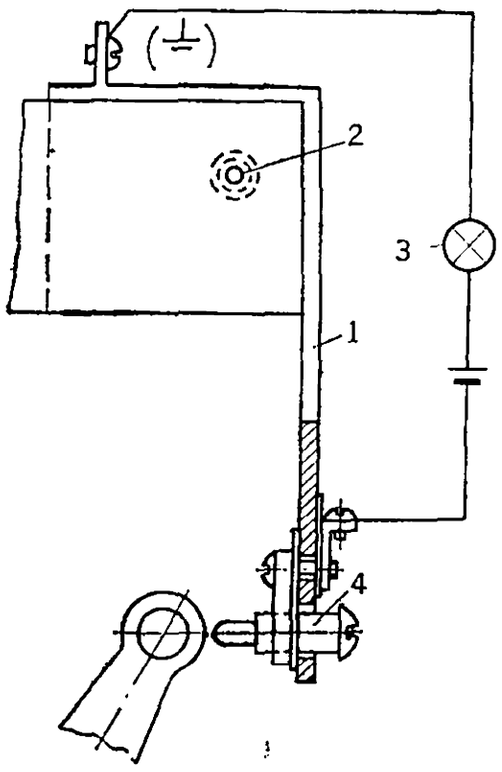

Fig. 130. Diagram of device for oil damper adjustment

torsion shaft and does not depend on the loom speed. With the main shaft set for narrow looms at 80° and for wide looms at 50° the clearance $a = 0.2$ mm is adjusted between the picking cam *2* (Fig. 129) and roller *8* (with the torsion shaft untwisted). The clearance *a* is adjusted by means of the bolt *9* and checked with a feeler through the aperture in the picking box provided on its right-hand side. Further, with the main shaft turned to 135° (for wide looms—100°), the scale attached on the housing *7* is set so that its division, corresponding to 0°, should coincide with the match mark on the winding coupling after which the torsion shaft is wound up.

In narrow looms the beginning of picking must be at the angle of (140 + 3)° and in wide looms at the angle of (105 + 3)° of the main shaft rotation. For adjusting the moment when picking starts (to avoid the breakage of comb toothing and of other parts, the weft inserters are extracted), the main shaft of a narrow loom is set to 250° and that of the wide loom to 220° and the torsion shaft is untwisted. Through the left-hand open aperture in the bottom section of the picking box, the bolts fixing the cam *2* to the three-slotted cam (not shown in the drawing) are released and the cam *2* is turned counterclockwise in case of early shed closure and clockwise in case of late shed closure. The cam is fixed, the torsion shaft is wound up and the moment of picking start is checked. Further, a clearance $b = 0.2 \ldots 0.4$ mm is set between the boss of the picker *5* and the side face of the weft inserter *6* (with the main shaft at 100° for narrow looms and 75° for wide looms). For this, the bolts *1* fixing the picking stick *3* are released and the latter is turned until the picker bears against the weft inserter side face. After tightening the bolt, the picking stick is displaced to the left and the necessary clearance is formed. This done, a clearance *c* from 0.05 to 0.1 mm between the lateral surfaces of the picking sticks and the striker *4* is adjusted by moving (the bolts being released) the fixture of the picking stick *3* along the picking tube.

For the adjustment of the oil damper a device is used consisting of the bracket *1* (Fig. 130) with spring-loaded insulated contact *2*, a battery for a flash light, and a lamp *3* for 3.5 V. These elements

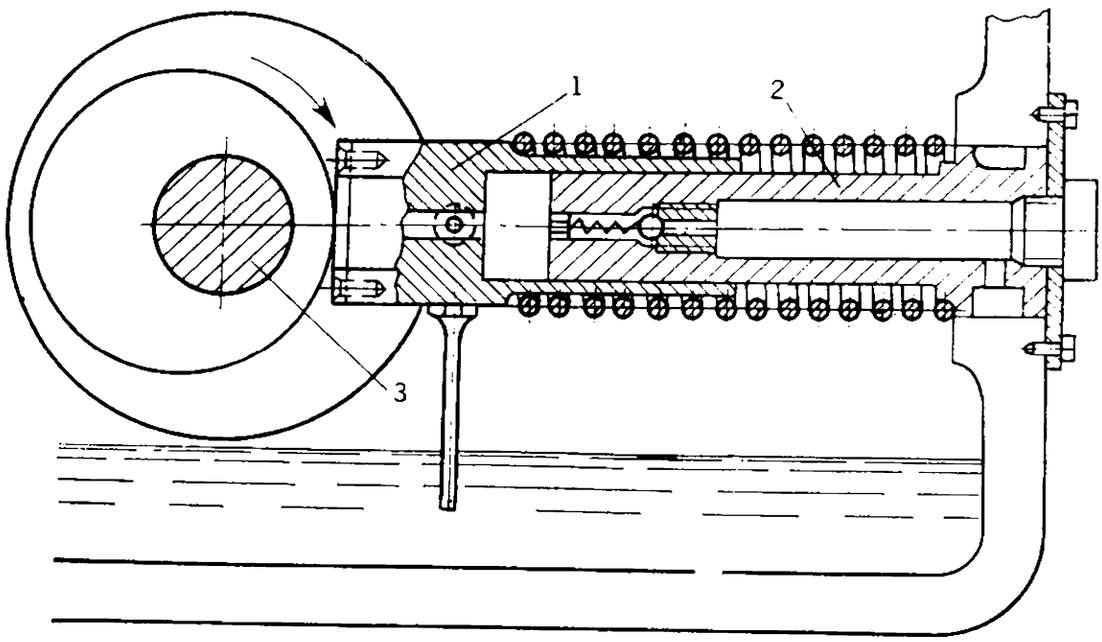

Fig. 131. Diagram of oil pump-atomizer

are connected as shown in the diagram. Prior to the installation of this device on the loom, the right-hand bolt *4* fixing the weft feeder guide (or the feeder guide shifter in wide looms) is unscrewed and the same bolt is used for fixing the bracket *1* of the oil damper adjusting device. The torsion shaft is wound up to an angle of 30°. After the installation and connection of the device, the shaft of a wide loom is set to 145° and that of a narrow loom to 110°. In this case the picking stick in front position should be without clearance and the weft fork feeler (not shown in the drawing) should not catch the contact *2*. Further, the loom is engaged in running. If the lamp lights up brightly it means that the piston damping is weak, and if the lamp does not light up at all the damping of the piston is excessive. In the former case, the needle is turned in until the lamp ceases to light up, and in the latter case it is first unscrewed until the lamp starts blinking and then turned-in until blinking ceases. This method of checking ensures a precise adjustment and reduces loom downtime required for damper dismantling.

The oil pump atomizer (Fig. 131) is intended for spraying oil to lubricate the weft inserter, the weft feeder guiding surfaces, the striker and other parts located in the picking box. If the side face of the cylinder *1* is worn (burred) by the action of the cam *3* more than over 2.5-3 mm, it must be repaired. The worn-out part is machined and a brass or bronze plate is fixed to it with two screws. At the replacement of the piston *2* or cylinder *1*, they are checked for easy running of the cylinder on the piston (with sufficient compression). In case of tight fit the working surfaces of the cylinder and pistons are to be wiped with paste.

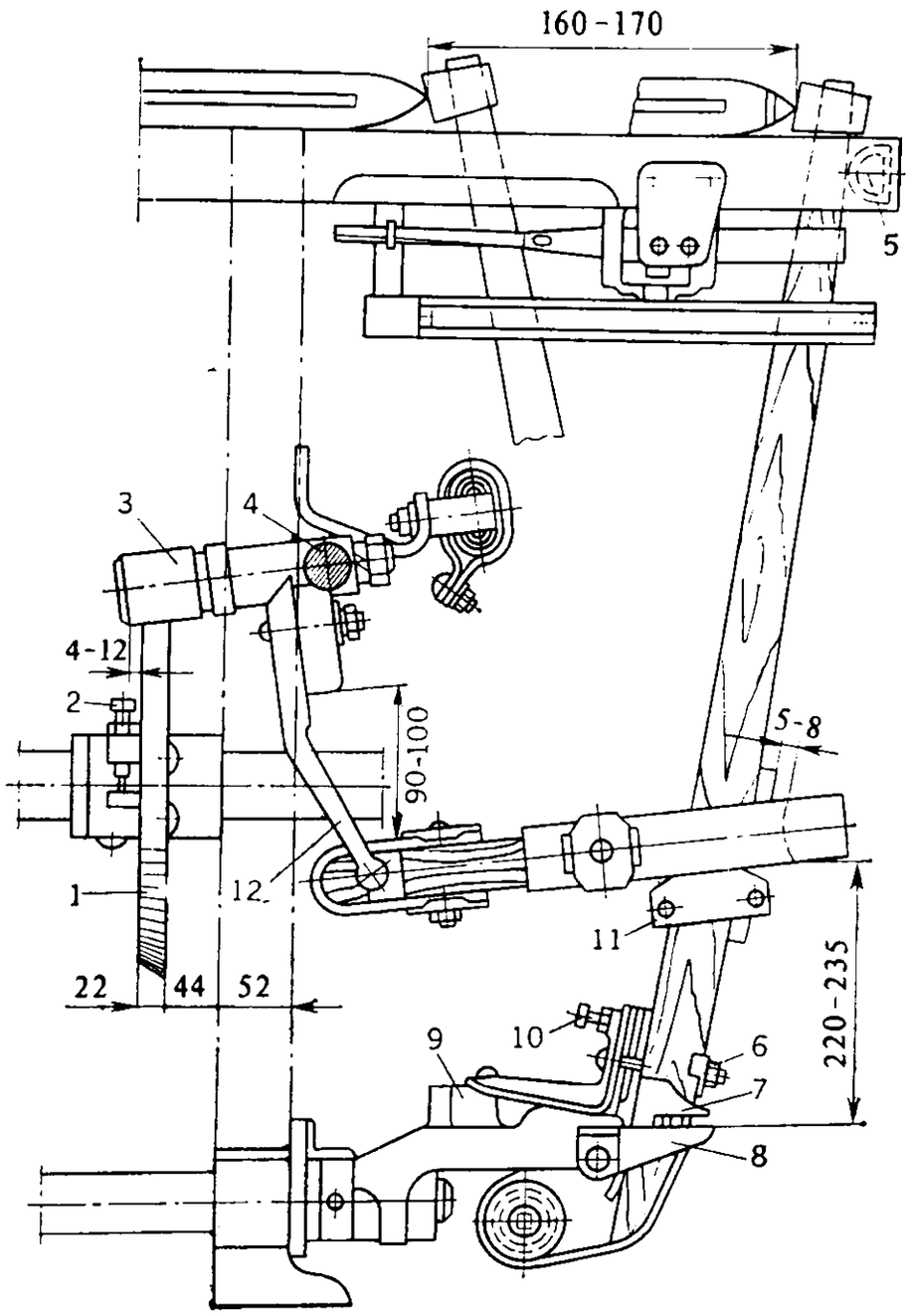

Fig. 132. Picking motion of type AT loom

Picking motion of a shuttle loom. As the picking motion is adjusted care should be taken that the spindles *4* (Fig. 132) are mounted strictly horizontal, easily rotate in bearings, and have no radial swing; their axial shift should not exceed 0.7 mm. The picking bowls *3* must tightly adhere without misalignment to the working surfaces of the picking cam *1*; the bowl at maximum lift should protrude over 4-12 mm from the edge of the picking nose bit and it must freely turn on the spindle; its longitudinal displacement should not exceed 1.5 mm. The picking cams should be 44 mm away from the flats on the frames. The surface of the picking cam should be free from indentations and protrusions. At the point of butting the picking nose bit and picking cam should be flush and the points of their

contact should be well finished. The working surfaces of the tongue and block must be smooth. The blocks on the bracket must be mounted so that a clearance of 10-15 mm is formed between the lug *9* of the bracket *8* and the interior wall of the cut-out in the block *7*. The surface of the bracket on which the block is moving must be smooth and rectilinear and the bracket should not have longitudinal shift. The picking stick should be 25-30 mm away from the slay end plate *5*. The stirrup *12* on the spindle should be mounted so that the distance from the top of the small shackle to the spindle lug is equal to 90-100 mm. When the picking stick is in extreme back position the clearance between the pickers and the metal race must be equal to 1 mm. The picker movement must be parallel to the race. For this, the picking stick must be inclined until the shuttle separates from the picker and then the bolt *10* is tightened until the picker lifts the shuttle 1 mm above the race. This done, the counter nut of the bolt *10* is secured and the bolt *6* is tightened. If the picker lifts the shuttle tip more than 1 mm above the race, the bolt *10* must be unscrewed until the picker lowers to form the necessary clearance, after which the counternut is secured and the bolt is tightened.

The beginning of picking is more easily adjusted from the left side of the loom with the main shaft turned through 70°, and from the right side of the loom to 75°. The beginning of picking is adjusted by displacing the picking cam on the coupling by means of the setting bolt *2*. For adjusting an earlier picking, the picking cam is turned in the sense of middle shaft motion. To adjust the beginning of picking at a later moment the picking cam must be turned in opposite direction. The force of picking is adjusted by the stirrup *12* and blocks *11*. For increasing the picking force, the stirrup and block are lowered so that the big shackle is 20-25 mm above the small one. For reducing the picking force the stirrup with the block is raised to a distance of 20-25 mm between the shackles. It should be noted that the smaller is the picking force, the smoother is loom operation and the less is the wear of loom parts.

When the picking nose bit is worn out, its curve is made steeper or the bit is replaced by a new one. When the picking bowl is worn out, it is replaced by a new one after oiling its spindle and checking its rotation on the axle.

The system for supply and distribution of compressed air in pneumatic looms. As the air supply system is repaired, it is frequently necessary to replace the air pipelines. Fig. 133 shows how the pipe end is to be prepared for replacement. The end of the pipe *1* of adequate length is tapered by filing and the nut *2* and pressure ring *3* are fitted upon it. Then, using a centre punch or any other bevel tool, the ends of the pipe are expanded thus forming the head *5*. This pipe end is inserted into the hole of the coupling *4* and the nut *2* is fitted upon it pressing with its lug on the ring *3* thus shifting it

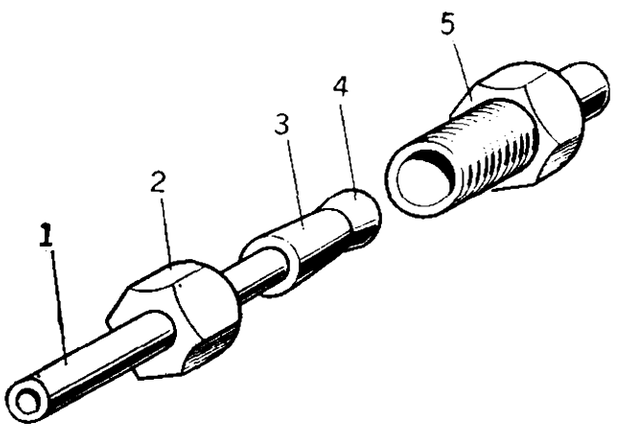

Fig. 133. Change of air distribution pipings in pneumatic looms

and pressing to the lugs of the coupling *4* the side face of the pipe *1*. Next the nut *2* is tightened and a checking for air leakage is made. In case of air leakage the operation is repeated so as to completely eliminate it.

The reducer is usually repaired in the fitter's shop after disconnecting it from all pipes and removing it from the loom. After dismantling the reducer, the bottom part of the frame, the hole in the box, the valve and plug surfaces are cleaned. In this mechanism the diaphragm is replaced more frequently than all other parts as it is forced-through in the middle part, distorted and lets air pass through the exterior walls. All other parts are replaced or restored when they are worn out. In the course of operation, capron pipelines are frequently deteriorated at the places of expansion and the nut becomes broken. Expansion of pipelines is made with an electric welding torch provided with a special nozzle.

Weft laying mechanism in ATIIP automatic rapier looms. The mechanism operates as follows. Two tubular rapiers penetrate into the open shed from both sides of the loom. When the rapiers meet in the middle of the shed, the weft yarn passes from the right rapier to the left one and is laid up to the left-hand edge of the fabric. The weft yarn is unwound from a stationary fixed bobbin with a constant speed by means of a measuring mechanism. With the aid of a compensator the yarn is supplied at variable speed first into the right-hand rapier and then to left-hand one. The rapiers are actuated by a drive and the air jets in the right- and left-hand rapiers are created either by an individual compressor mounted on each loom or by a centralized air supply system. The weft laying mechanism consists of three parts: the rapier displacement mechanism, the weft yarn supply mechanism (measuring mechanism and compensator) and the air supply mechanism (compressor and air ducts).

As the rapier mechanism is adjusted (Fig. 134) it should be taken into consideration that in meshing gears the generatrices of their conical surfaces must completely coincide. The proper meshing of bevel gears is checked by the contact stain (Fig. 135). A thin layer of paint is applied on the teeth of the gear z_1, after which the gear z_1 is turned while the gear z_2 is slightly braked. A normal contact stain (Fig. 135*a*) must be disposed in the middle of the tooth profile and must occupy at least half of its height; in length it must be displaced to the thin part of the tooth (without coming out of its limits).

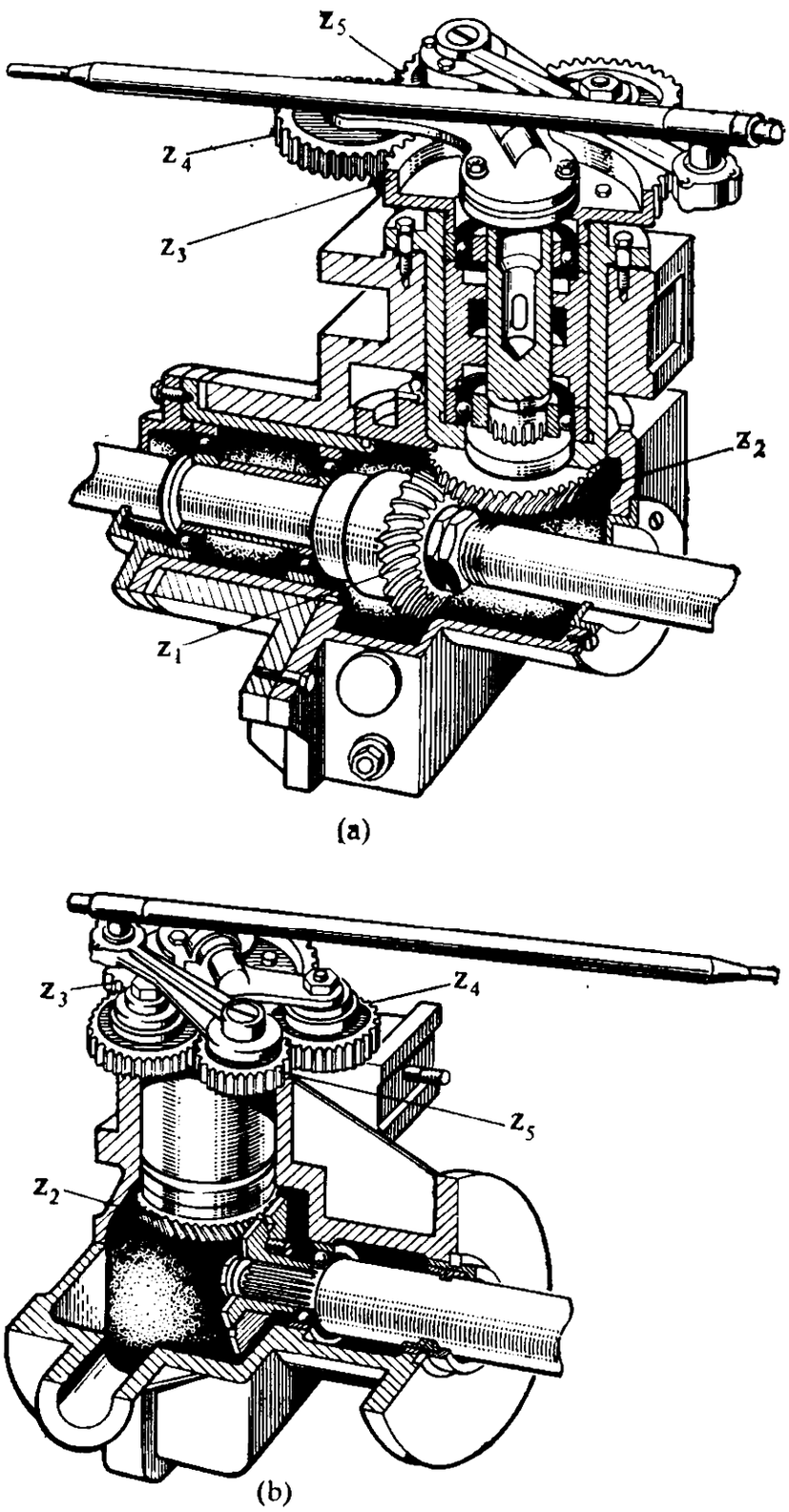

Fig. 134. Rapier mechanism of type АТПР loom
(*a*) right-hand part; (*b*) left-hand part

If on turning the gears in both sides the contact stain is located differently (Fig. 135*b*, *c*), the gear meshing is adjusted by inserting gaskets under the sleeves of the horizontal and vertical shafts (Fig. 135*d*, *e*). The gaskets are extracted from under the sleeves consecutively so as not to impede the proper tooth meshing. To begin

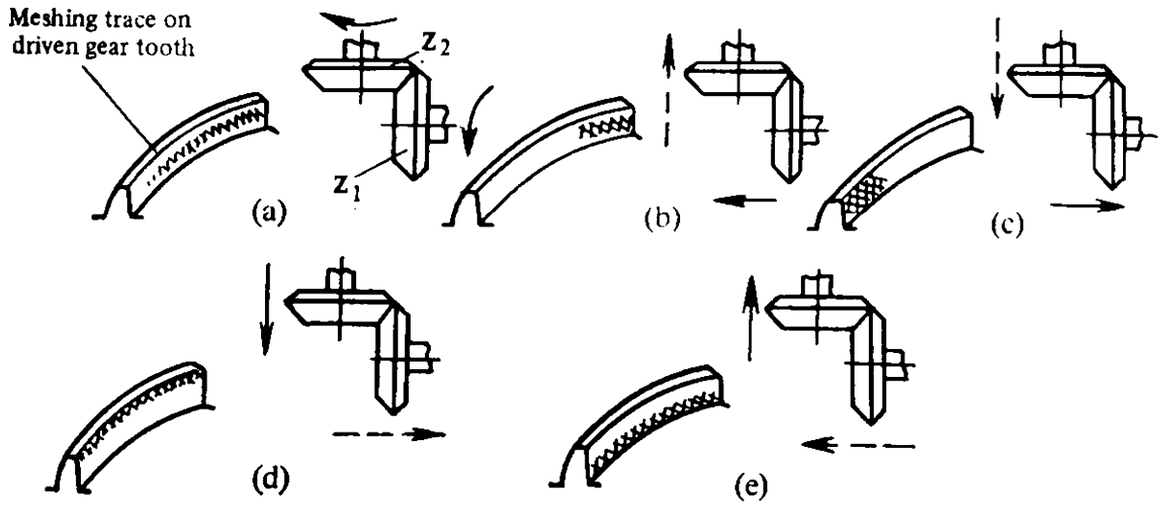

Fig. 135. Adjustment of bevel gear meshing

with four bolts fixing the sleeve of the vertical shaft and four bolts fixing the sleeve of the main shaft are to be unscrewed; after the adequate gasket has been chosen, the bolts are tightened again. The allowable minimum side clearance between the teeth is from 0.1 to 0.2 mm. During loom operation in the weaving shed, this clearance may be checked by means of an indicator at four points in every 90° of main shaft rotation. When the arm length is 250 mm the side clearance must be equal to 0.5-0.8 mm. The clearance is adjusted using the same gaskets under the sleeves: the normal meshing of bevel gears is characterized by noise emitted during mechanism operation, i.e. a light hissing or buzzing. When adjusting a minimum side clearance in the meshing of the sun gear z_3 (see Fig. 134*a*, *b*) the satellite gears z_4 and the planetary gear z_5, the clearance is determined by the slight manual swinging of the connecting rod and the clearance is eliminated by displacing the shafts of the satellite gears in the elongated side hole provided in the carrier plate.

The carrier in assembly with the connecting rod is checked for run-out prior to the installation on the loom using a special device (Fig. 136). A bevel support and measuring instrument (a calliper square or a gauge) which may be displaced on the plate are placed on the smooth surface *1* of the checking plate not less than 500 × 500 mm in size. The carrier *4* in assembly with the connecting rod *2* are inserted in the hole of the bevel support. The run-out of the surface *3* in respect to the surface *1* is checked by rotating the connecting rod in respect to the axis *aa*. The distance from the surface *1* to the surface *3* is measured at the end of the connecting rod at four points. On each rotation of the main shaft through 90°, the run-out should not exceed 0.25 mm. If the run-out is greater than is allowable, the carrier is to be replaced or straightened. When checking the carrier and connecting rod for proper mounting on the loom, a gauge and a ruler are used. The distance from the connecting rod surface to the

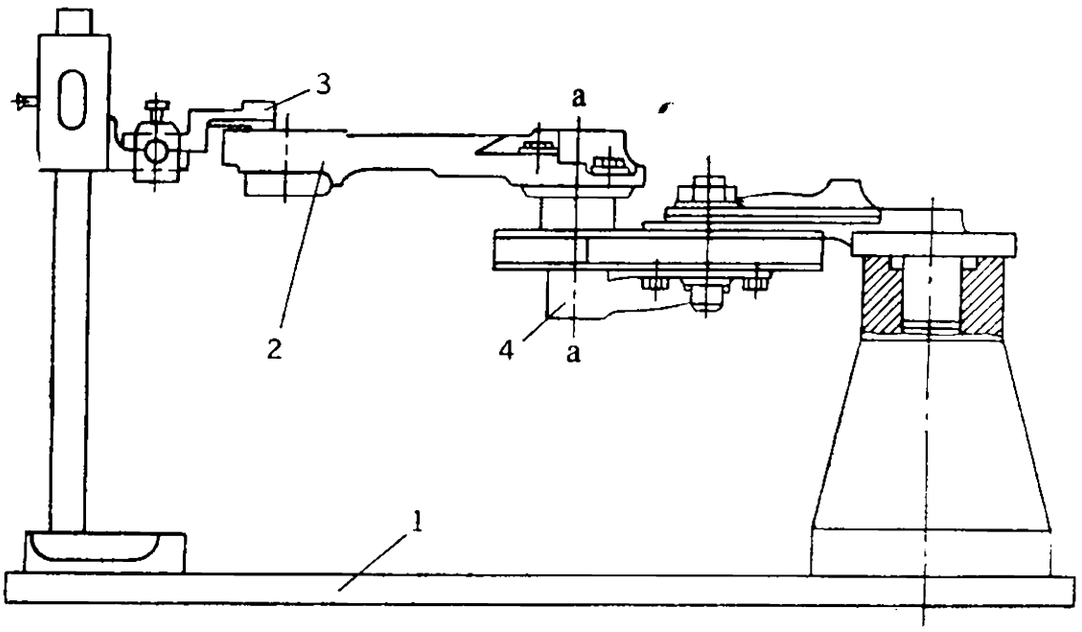

Fig. 136. Device for checking carrier for run-out

ruler is checked at four positions of the carrier. The difference in readings should not exceed 0.6 mm.

The rapiers are mounted at the moment of picking when the main shaft is in 0° position (here, the rapiers must completely be set apart). If the position of the rapiers is to be adjusted, the unfixed carrier is turned in respect to the vertical shaft. After the adjustment has been completed, the carrier is secured with bolts and a pin. The axes of symmetry of the rapiers, connecting rod, planetary and sun gears must be on the same straight line. An adequate adjustment is made by turning the sun gear in the slots in respect to the sleeve. The proper displacement of the rapiers is checked by the manual smooth turning of the sleeve shaft.

The penetration of the rapiers into the shed or their displacement to the level of the extreme reed dents must occur simultaneously from both sides (the admissible difference is not more than 5 mm). As they enter into the shed, the rapiers must not come in touch with the reed and must slide on the reed only with their cover plates made of textile-based laminate. The clearance between the nozzle of each rapier and the interior top wall of the guide must be equal to 2 mm. The rapiers are adjusted in height by changing the number of gaskets between the carrier flanges and the shaft. The clearance between the nozzle and the interior wall of the guide from the side of the breast beam must be at least 1 mm. When the main shaft is at an angle of 180°, the rapiers must occupy the extreme position in which they are brought together, and the distance between the rapier ends must be equal to 2-5 mm.

When checking the air duct system, the loom main shaft is turned to 270°, the right- and left-hand top guards are opened and inserting

a wooden bar between the carrier and the back wall of the guard one of the planetary mechanisms is braked, which is followed by braking of the loom main shaft. It is necessary to ascertain the reliability of braking when the friction clutch is fully engaged since checking and adjustment are carried out with the motor on. Next, the right-hand starting crank is shifted to the left along the slot, but in no case should it be drawn towards the operator. In its new position the crank is locked by inserting a wooden wedge. When the compressor is working, the pressure according to the gauge connected with the receiver should not be under 35 kPa at full stroke of the compressor piston. If the pressure is lower, it is necessary to locate the point of air leakage by feeling with the palm the jet of leaking air. The leakage is eliminated by tightening the bolt joints and by replacing the gasket or packing rings, especially under the carrier and rapier.

With the loom in the same position, the rapiers are checked for maximum rarefaction. For this, the hose connected with the compound pressure-and-vacuum gauge is fitted first on the nipple of the right-hand rapier and the nipple is turned until a zero reading is obtained on the gauge scale. For creating the vacuum, the nipple is tightened clockwise over a quarter of a turn at which the pressure-and-vacuum gauge readings should not be under 25 kPa. Next, the hose from the pressure-and-vacuum gauge is introduced through the shed and fitted on the pointed end of the left-hand rapier. Turning the nipple a maximum vacuum is created in the rapier; the readings of the pressure and vacuum gauge should not be under 10 kPa. After the adjustment of the rapiers is completed, the loom must be released from the stop and the guards are to be closed.

The preventive inspection and repairs of the rapier drive is carried out in the following order: the level of oil and its quality are checked in the drive box; the clearances and meshing of bevel gears and planetary drive gears are checked; the position of the rapiers in respect to their guides, the clearance between the rapier cover plates and reed, and the proper displacement of the rapiers throughout the length are checked; the good sealing of the system is ascertained and the adjustment of the rapiers for maximum rarefaction as well as the good and clean condition of air canals is checked; the proper lubrication; and the good state of all bolted joints are verified.

The rapiers to be repaired are removed from the loom and sent to special repair shops where it is established whether the rapiers must be partially or completely disassembled, the worn-out parts are replaced and the rapiers are assembled and adjusted. The adjustment of the rapiers after repairing is carried out on a special stand made as a table with air duct from the shop mains *4* (Fig. 137). The left rapier nozzle is inserted in socket *6* to which the compressed air is supplied and using the pressure regulator *3* connected by hose with the pressure gauge *2*, readings of 40 kPa are obtained. On the rapier

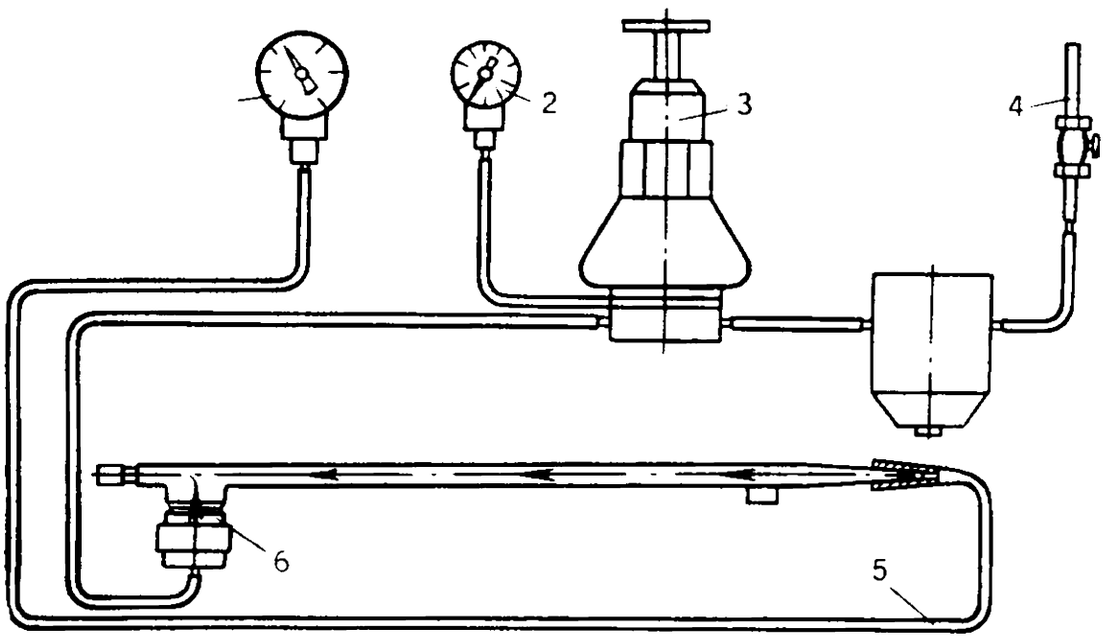

Fig. 137. Testing rapiers on stand

end a rubber hose *5* is fitted running from the pressure and vacuum gauge *1*. The maximum vacuum in the rapier is adjusted by tightening and unscrewing the nipple. The readings on the pressure and vacuum gauge scale should not be under 20 kPa, and if the readings are lower, the rapier should be assembled anew or rejected. During rapier checking, the pressure gauge readings may deviate and in this case the air supply must additionally be adjusted according to pressure gauge reading (40 kPa).

The right-hand rapier is mounted in the same way, with the difference that the rubber hose *5* is fitted on the rapier nipple. The pressure according to the gauge must be equal to 60 kPa and to the pressure-and-vacuum gauge not under 34 kPa.

The timely and properly dozed lubrication of the pneumatic rapier mechanism ensures a long and trouble-free operation. Lubrication is carried out in conformity with the schedule in which the periodicity of lubrication and the kind of lubricant used are stipulated. For the lubrication of the right- and left-hand rapier driving boxes, automobile gear box oil is used. Oil is changed every six months and added as need occurs. The oil level in the shells must correspond to the middle of the scale on oil indicators. The right-hand box is filled with 250 cm^3 and the left-hand box with 750 cm^3 of oil. The plugs, oil indicators, inspection covers must properly be tightened and fitted to bearing surfaces to avoid oil leakage. The ball bearings of the vertical shaft, of the planetary gear shafts, of the carrier and rapiers are to be lubricated with cup grease every six months. For greasing the vertical shaft bearings, it is necessary to turn out one of the bolts attaching the carrier to the shaft and to insert in its place a special adaptor reducer with an oiler. Oil is supplied with a grease gun until

it appears in the bearing clearances. The grease coming out of the bearing must be eliminated. The penetration of the grease in the air ducts to the rapiers is absolutely unallowable because the conditions for normal yarn laying would be impaired. If nevertheless grease has penetrated in the air ducts it must be carefully eliminated by wiping the canals of the rapiers, connecting rod, carrier, and vertical shaft. It is also necessary to check the presence and condition of oil packing rings and collars.

Slay Mechanism

Slay mechanism of the СТБ shuttleless loom. The slay serves as a guide for the flight of the inserter with the weft yarn through the shed and effects beating-up of weft yarns to the fabric fell. The main condition for the long and trouble-free operation of the slay guide consisting of a row of plates forming a canal for the passage of the weft inserter is its coaxiality with the picking and receiving boxes and its proper mounting. The adjustment is carried out as follows. With the main shafts at 0° in narrow looms, or at 35° in wide looms, the weft inserter is extracted through the plug and next having turned the main shaft to 70° (50°) from the side of the receiving box, the gauges *A*, *B* and *C* are consecutively introduced into the guiding dents of the slay (Fig. 138). Further, the shaft is turned to 150° (110°) and the gauge *A* is displaced along the slay guide in the sense of the picking box. The dents impeding the free passage of the gauge are replaced by new ones. When the gauge reaches the picking box it is shifted in the weft inserter guide. The gauge must freely enter into the guide. On the displacement of the gauge horizontally in respect to the guide aperture, the extreme slay swords are released by shifting the slay beam in horizontal direction, or steel gaskets are inserted between the slay swords and beam. If the slay is mounted higher, the two extreme swords are removed and the coaxiality is obtained by sawing off the point of seating. The displacement of the gauges *B* and *C* is effected in the same way.

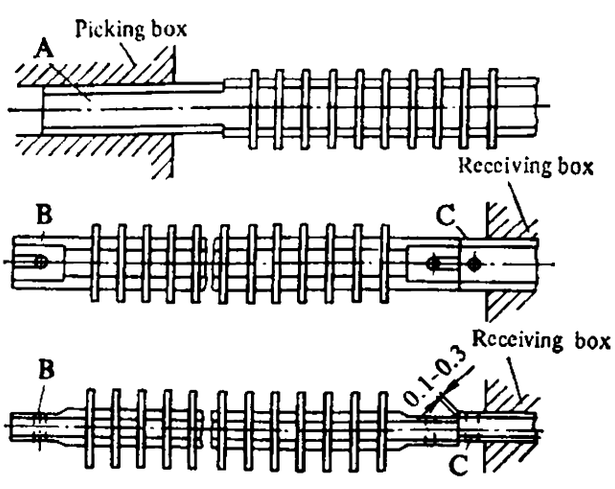

Fig. 138. Diagram of checking guiding comb of the СТБ loom
(*a*) picking box; (*b*), (*c*) receiving box

In the course of slay mechanism operation, the wear of surfaces of the coupled cams and rollers of the slay shaft bronze bushings results in backlash appearing between the cams and rollers, bushings and shafts.

The backlash is eliminated by disassembling the slay mechanism. Worn-out bushings are replaced by new ones. For bushing replacement a special puller (Fig. 139) is used consisting of a shaped nut *2*, bolt *5*, pipe *4* and washer *3*. The shaped nut *2* is inserted inside the bushing so as to have its rims butting against the edges of the bushing. Next, the bolt *5* is inserted in the hole of the washer *3* and the latter together with the bolt is placed in the pipe *4* so that the washer rims rest on the pipe. When the bolt *5* is turned into the shaped nut *2* the latter begins to move to the right pressing out the bushing *1* from the box *6*. For inserting a new bushing into the box *6*, the shaped nut *2* is placed inside the bushing and inserted in the interior part of the box *6*; the bushing edges are preliminarily pressed into the box opening by slightly knocking with a copper hammer. After this, the washer *3* is pressed to the exterior box and the bolt *5* is inserted into the washer hole by screwing it into the shaped nut *2* mounted from the interior side of the drive and thus displacing (press-fitting) the bushing in the hole of the box *6*.

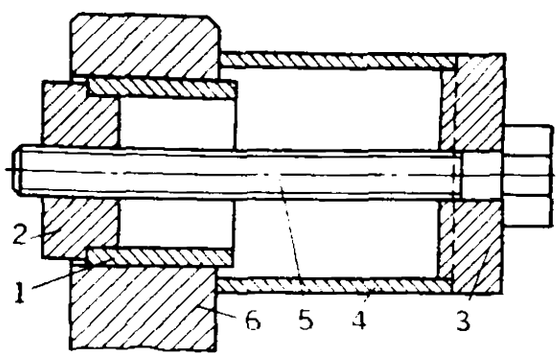

Fig. 139. Diagram of puller for replacing bushes of slay mechanism for СТБ loom

If both cams (the cam and countercam) are turned over a full revolution and the clearance remains the same but exceeds the allowance of 0.03 mm, it is eliminated by choosing an adequate top roller (the bottom rollers must remain the same). If the clearance between the cam and roller varies in magnitude the greatest clearance shows the wear of their surface. In this case, the camshaft must be replaced.

When replacing the gland body in slay boxes or the gland in the frame, the latter is pressed out from the slay box. For this, in the side face of the gland body, holes are drilled with a thread M6 cut inside. The screws are then turned into the holes so as to have their side face butting against the ball bearing shell. On further rotation of screws, the gland body is pressed out. After the gland has been repaired and its body press-fitted in the slay box, the drilled holes are closed by screws and glue to avoid oil leakage.

The slay mechanism of shuttle looms. The slay mechanisms may be subdivided into fast reed and loose reed mechanisms; mainly a crank fast reed slay mechanism finds application.

To adjust the slay mechanism, the following requirements are to be satisfied. The slay shaft must be horizontally disposed, and must easily rotate in the bearings; its axial displacement should not exceed 1 mm and radial swing —0.5 mm. If the swing exceeds the

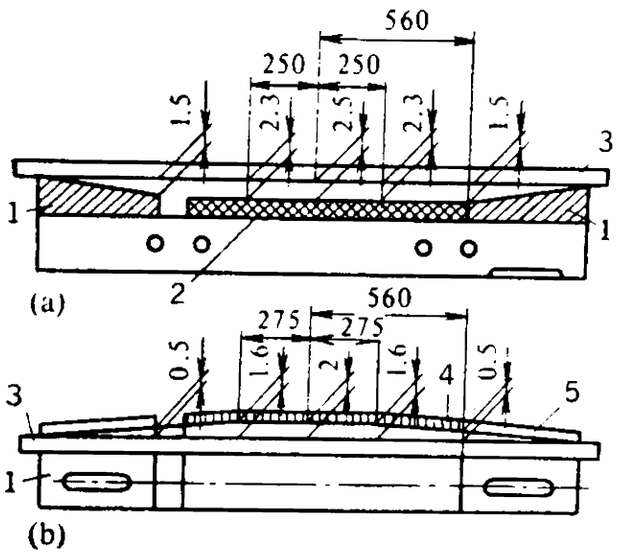

Fig. 140. Positioning of slay recess and declination of shuttle boxes backs

allowable value, the bearings of the bottom shaft must be replaced. Longitudinal shift is eliminated by means of setting rings fitted on the slay shaft. The distance from the centre of the slay shaft to the flat on the slay sword heads must be equal to 600 mm and from the inside surface of the frame to the exterior surface of the sword—25 mm. The carriers must be connected with the sword without misalignment. When the mainshaft crank is in back position, the swing of the swords with carriers must not exceed 1 mm, as otherwise the stud or bushing of the carrier bearing must be replaced. The angles between the reed and the wooden race as well as between the front and back of the shuttle boxes and metal races must be equal to 90°. For angle checking a square is used. The exterior ends of metal races *1* (Fig. 140*a*) must be 1.5 mm higher than the interior ends of the wooden race. The races (two metal races and a wooden one) form a smooth curve throughout the whole length. In the middle of the wooden race *2* the clearance is equal to 2.5 mm, on both sides at a distance of 250 mm from the middle—2.3 mm, and at points of metal race abutment with the wooden race—1.5 mm. These clearances are checked with the control ruler *3* placed on both ends of the metal races. The gap between the bottom edge of the ruler and the surface of the races must correspond to the dimensions indicated in Fig. 140*a*. If the actual dimensions differ from the recommended ones, the wooden race is replaced by a new one. The surface of the wooden race must be free from indentations; the place of metal race abutment with the wooden race is made flush. When the ruler *3* (Fig. 140*b*) is placed on the ends of the shuttle backs, a clearance formed between the ruler *3*, the reed *4* and the shuttle walls *5* is called the *slay declination*. The declination in the middle of the wooden race is equal to 2 mm, at a distance of 275 mm on both sides from the middle—1.6 mm, and at the points of shuttle backs abutment with the reed—0.5 mm. When the ruler is laid on the shuttle box swells, the clearance should show from 4 to 5 mm which is called the *swell declination*.

The centre of the shuttle tip in the box must be in the middle of the metal race slot. The clearance between the shuttle box fronts and shuttle must be equal to 2-3 mm at the entry of the shuttle into the box. The exterior surface of the weft fork grate must coincide with

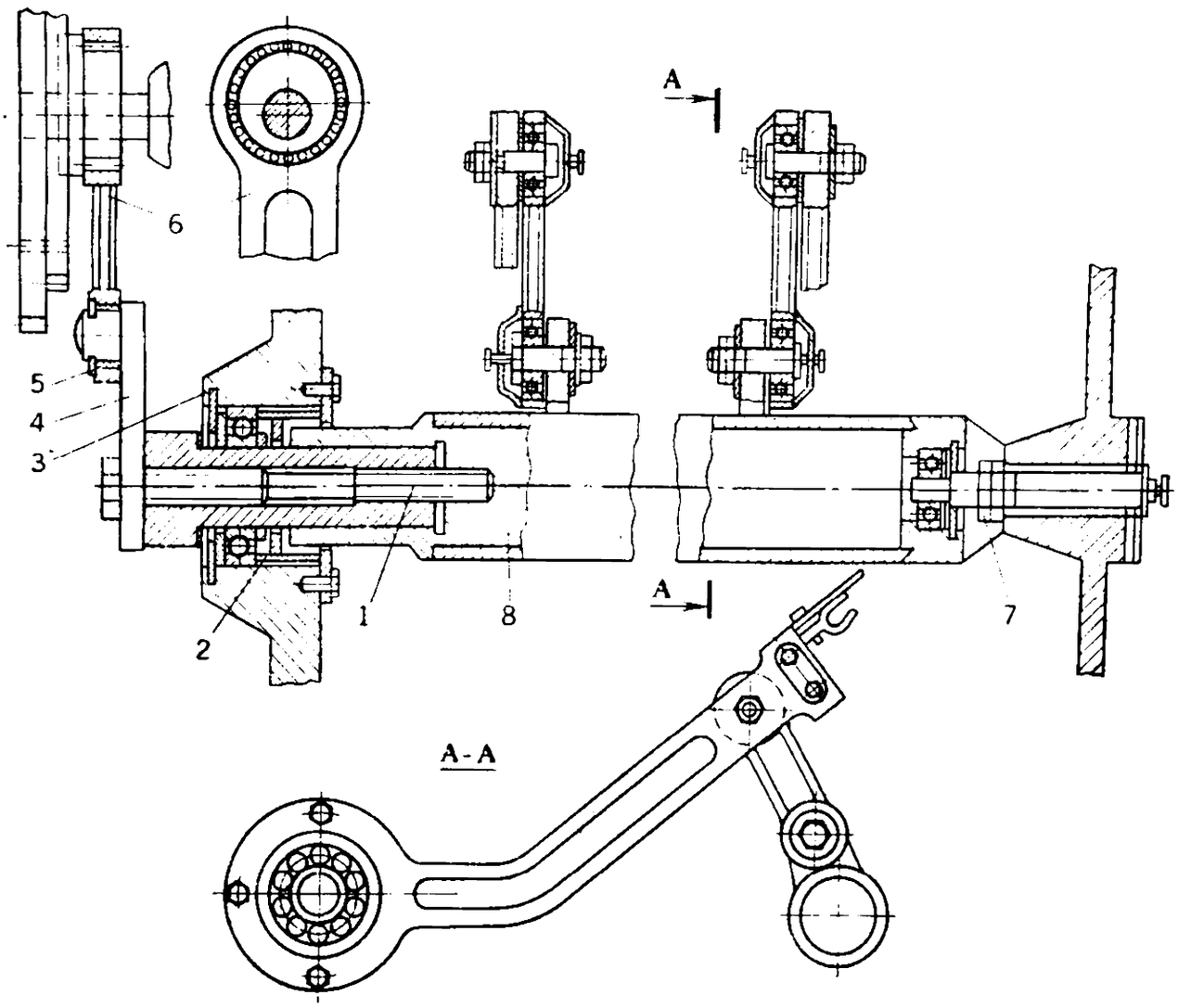

Fig. 141. Diagram of slay mechanism in type P loom

the smooth curved line of the shuttle backs and reed declination. The angle of sword oscillation must be equal to 11°. The deflectors guiding the shuttle into the shuttle box must be mounted on the sword so as to obtain a distance of 2 mm between the upper edge of the shuttle back wall and the deflector. The rod protecting the shuttle from falling-out must be disposed 10 mm above the temple and must not come in contact with the warp yarn. When the swell belts and the check strap are worn out (the wear is allowable over 1/3 of the belt initial thickness) they must be replaced. Broken carrier rods are repaired by welding or replaced by new ones.

Slay mechanism of a pneumatic loom. The upper part of the mechanism carries the confuser and the reed attached by special bolt-pins. When the bushing *5* is worn-out (Fig. 141), it is replaced by a new one which is press-fitted into the connecting rod *6*. For the installation on the loom of the rocking pipe *8*, the crank *4* with the gland *2* is inserted into the sleeve and the set ring *3* is put in place. Next, the bolts *1* are screwed into the crank *4* leaving a gap of 40 mm

from the bolt head to the crank surface. After greasing the crank bevel surfaces and the pipes, the rocking pipe *8* is drawn by the bolt *1* over the crank *4* until the distance from the bolt to the crank surface is equal to 14-17 mm. If in this case the bolt turns easily enough, it means that the bevel surfaces are not mating correctly and that the pipe is not fixed on the crank and must be replaced. If no spare rocking pipe is available, a soft foil is inserted under the bevel surfaces, the pipe is again fitted, the bushing is shifted to the left, the nuts *7* are tightened and the setting conductor is extracted. This done, the pipe must easily rotate, but without axial shift.

In pneumatic looms, to avoid air leakage from the left-hand cabinet, glands of different sizes are used. At the time of repairs, these glands must be replaced. Usually the glands are fitted on the shaft neck from smaller to greater diameter which may cause damage of the gland inside surface.

For fitting the glands on the shafts special bushings with one tapered end may be used. The exterior diameter of the polished bushing must strictly suit the diameter of the shaft on which the gland is to be fitted. In this case, the gland will easily pass from the bushing onto the shaft surface. The field of use of such bushes and their dimensions are given in Table 12.

Table 12. Main Dimensions of Bushings

Outside diameter *D*, mm	Inside diameter *d*, mm	Bushing height *H*, mm	Cone height *h*, mm	Mechanisms for which the bushings are used
37	$28^{+0.2}$	35	10	Camshaft
39	$30^{+0.2}$	44	12	Splined shaft
18	$16^{+0.2}$	70	15	Starting crank roller (sleeve-shaped bushing)
29	$25^{+0.2}$	18	9	Main shaft cover
25	$20^{+0.2}$	30	15	Take-up mechanism cover
18	$13^{+0.2}$	36	15	Measuring mechanism shaft
23	$18^{+0.2}$	40	15	Left-hand cabinet cover

The reed attached in the slay beam is subjected to considerable loads especially in high speed looms (up to 1000 N and more) and also to vibrations. Moreover, the reed dents are rapidly worn out by running against the warp yarns. The main disarrangements of the reed are: the failure of soldered seams, slackening of fixtures, shattering and breakage of dents. The longevity and reliability of reeds may be increased by using reinforced (wider) chromium-plated dents (of 4 mm rather than 2.8 mm wide), or by employing glues instead of soldering to fix the reed dents. The second method is the most efficacious from the point of view of reed reliability. Moreover, the

reed worn-out parts can easily be replaced without wasting much time. In silk looms available are reeds having dents coated with wear-resistant and anticorrosive chromium. The reeds working in the conditions of high humidity have dents of stainless steel.

Warp protector motion of a shuttle loom. This motion protects the warp yarns from breaking if in weft beating-up the shuttle would remain in the shed or would not completely enter into the shuttle box. When the warp protector motion comes in action it causes loom stoppage.

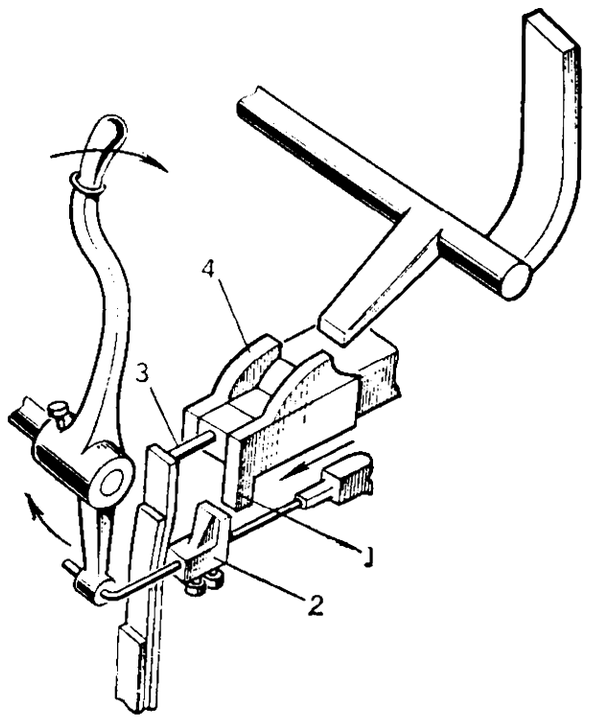

Fig. 142. R.H. protector pad of type AT loom

The adjustment of the warp protector motion must be carried out so as to satisfy certain requirements. The stop rod must easily rotate in bearings and its longitudinal shift must not exceed 1 mm. At the moment when the warp protector nibs exercise their action on the stop pad frogs, the distance from the fabric fell to the reed must be 65-67 mm. (Knocking of the warp protector nibs against the frogs.) The distance between the warp protector pad and the frame must be equal to 20 mm. At the moment when the warp protector nibs come in contact with the pads, the latter should move forward not more than 10 mm, as otherwise knocking against the frame can occur. When the shuttle completely enters into the shuttle box, the warp protector nibs should be 2-3 mm above the stop pad frogs. When there is no shuttle in the box, the warp protector nibs must be 1-1.5 mm above the edges of the pads and simultaneously must approach both frogs; if this clearance is impaired, the protector pad nibs come in touch with the pad which is unallowable. There should be no clearance between the adjusting bolts of the protector fingers and the swells of the shuttle boxes. The springs of the shuttle box swells must be adjusted for a minimum effort just sufficient for returning the swell and stop rod in initial position after the working travel.

When the stop rod nibs knock against the frogs, the warp protector motion must rapidly disengage the starting cranks; for this it is necessary that a clearance of 1-2 mm is maintained between the lug *1* (Fig. 142) and the stand *2*. Provided the stop rod is properly set, the warp protector nibs must freely lower on the pads without spring assistance. The proper adjustment of the warp protector motion is checked as follows: with the loom motor off, the starting cranks are

engaged and turning the main shaft the warp protector nibs are brought to the frogs; having ascertained that the nibs approach simultaneously the frogs, using the handwheel the operator should turn the main shaft and the warp protector nibs must knock off the starting handles through the intermediate of the stop pads.

In the absence of the shuttle in the shed both nibs must tightly rest on the frogs. If one nib does not rest on the frog, it is necessary to release the shell fixture, and slightly turning the stop rod press it to the frog, after which the shell must again be rigidly fixed. If the pads move with difficulty or the springs are slack, the warp protector nibs may be broken. In this case, they must be replaced with new ones. The stop protector pads may be broken if the rubber dampers are worn-out, the rods *3* (see Fig. 142) of the pad *4* are improperly mounted, and the pad strongly swings on the frame. The insufficient lift of nibs causes the wear of their bottom parts and of the pads. In case of improper adjustment and lengthy operation of the loom, the working faces of the frog nibs, as well as the rubber damper of the pads, become worn-out and must be replaced with new ones.

Warp Delivery and Cloth Take-up Motions

Warp delivery motion in the СТБ shuttleless and АТПР rapier looms. The warp delivery or let-off motion used in these looms is of the negative action, i.e. it lets off the warp from the weaver's beam depending on the tension applied. This motion is designed to maintain the adequate tension of the warp and to ensure its automatic supply in accordance with the fabric winding by the cloth take-up motion.

The adjustment of the warp delivery motion is effected as follows. With the main shaft at 200° the highest point of the boss *9* (Fig. 143) should be opposite the roller *1*. At this moment, the roller must be pressed to the highest point of the boss and the link *7* must occupy the middle position in respect to the shaft *6* or must be somewhat higher. The distance between the neck of the backrest and the thrust plate *3* must be 15-20 mm. When the link is lowered (before the roller presses against the boss) the backrest neck must closely fit the thrust plate *3* and the dimension *a* should be equal to 50 mm. This dimension is set by turning the eccentric bushing *11*.

Disarrangements in the warp delivery motion result in irregular warp supply or jamming of weaver's beams. The causes of warp irregular delivery and consequently of fabric defects such as set marks, starting marks, cross streaks, may be the result of boss wear, i.e. the appearance of a horizontal area on the surface (see Fig. 143); the wear of friction cover plates *10* causing a slight braking of the driven disk and its slippage by inertia; the getting of oil on the fric-

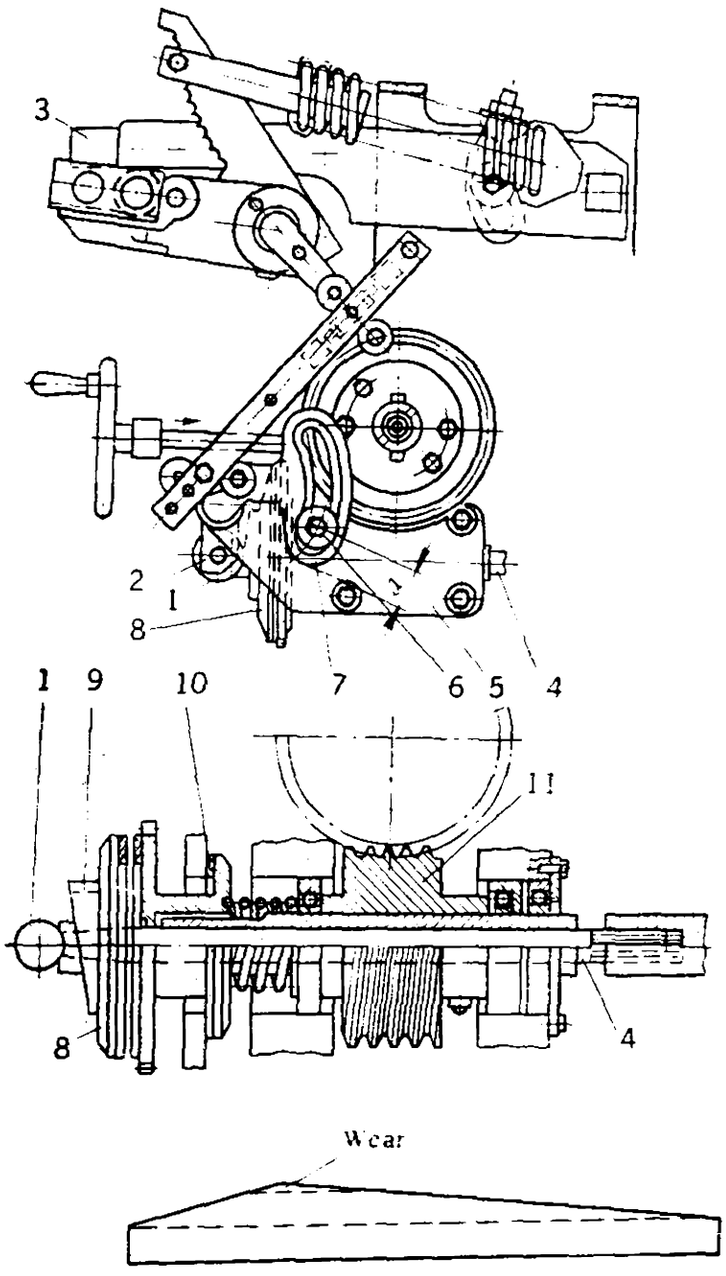

Fig. 143. Diagram of warp delivery motion for СТБ and АТПР looms

tion disks; a strong wear of friction rings on the driving and driven disks and the jamming of weaver's beams.

The boss wear is eliminated by building up a metal layer on the horizontal areas with further grinding on a grinder so as to obtain a strictly adequate profile. For removing the disk with the boss, the nut attaching the disk *8* to the roller *4* is released, and by tapping on it the disk is disconnected from the roller. Next, the cover of the weaver's beam bearing is removed and the disk is extracted. When the friction cover plates are worn, the warp delivery motion is disassembled, the worn-out cover plates are removed and new ones are *fixed in their place*. The best results are obtained by using cover plates cut out from a copper-asbestos (woven) belt. Worn-out fric-

tion rings are also replaced by cover plates cut of copper-asbestos belt. By using such cover plates the useful life of the friction clutch is increased 5-6 times.

Weaver's beams jamming is usually caused by articles accidentally fallen in their gearing, by weaver's beams catching the medium bearing bracket, the radial run-out of gears due to the absence of one bolt in the weaver's beam barrel, gears, or weaver's beam shaft couplings and also by the noncoincidence of the weaver's beam bolts with the gear and coupling bolts. With the proper assembly, the bolts must be on one side. In the course of loom operation, the link lowers due to the progressive wear of the friction cover plates. However, the friction cover plates are not completely worn out and may be still used. In this case the body *5* is removed, the wedge is knocked out (the one which is usually driven from outside) as well as the fixing lever *2*, and a wedge is driven in from the inside which allows the inclination of the lever with the roller in the direction of the boss. This displacement of the wedge ensures a considerable increase in the useful life of friction cover plates.

The warp delivery motion in automatic shuttle looms. These looms are provided with two types of warp delivery motion or regulators for tensioning and letting-off the warp, i.e. planetary and worm wheel let-off motions.

Planetary regulator or selected let-off motion. At the installation and adjustment of the planetary regulator, it is necessary to observe the following recommendations. The regulator shaft *1* (Fig. 144) and the roller *17* of the warp feeler must easily rotate in the bearings without misalignment and longitudinal shift. The weaver's beam gear *27* and the underbeam gear *25* must mesh with their initial circumferences so as to have a clearance of 2 mm between the head of the teeth on one gear and the tooth root on the other gears. Both gears must be flush in width. The flange of the beam *26* must not contact the underbeam gear *25*, the bottom link *23* must easily rotate on the regulator shaft and the top link *5* on the spindle *6*. No longitudinal displacement of links is allowed. The clearance between the rims of the top and bottom links must be equal to 8 mm and the tie rod *24* must easily move inside this clearance. The link roller *4* must also easily move along the slots of both links. The warp feeler *15* and lever *22* must be attached on the roller *17* so that the distance (*L*) between the centre of the top link spindle *6* and the link roller *4* should be as follows:

Winding diameter of warp on the beam, mm	*L*, mm
530	85
500	102
450	111
400	123

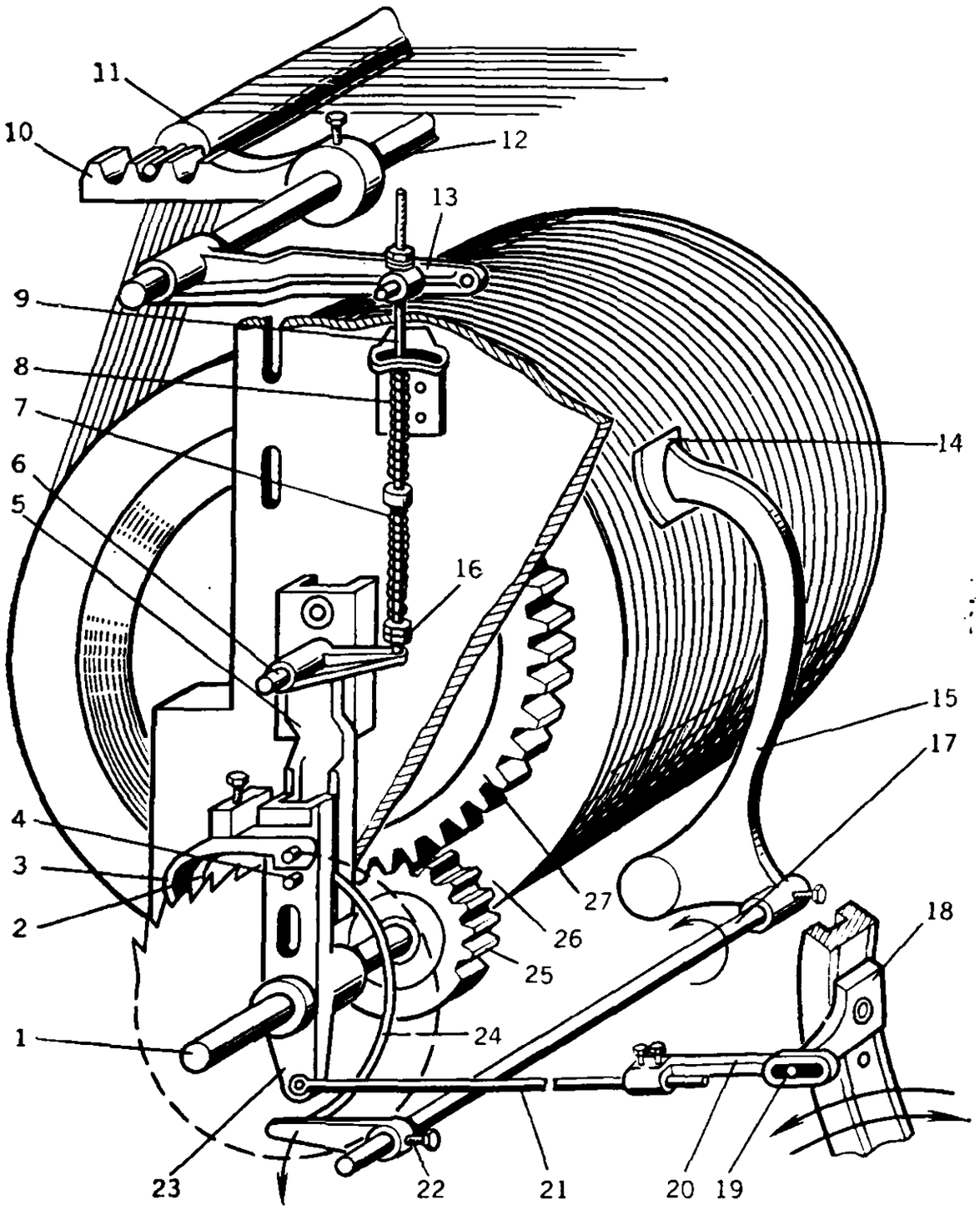

Fig. 144. Planet-type warp let-off and tension regulator in type AT loom

Thus, the size *L* depends on the winding diameter of the warp on the weaver's beam: the smaller is the warp winding diameter, the greater is the dimension *L* and vice versa. The foot *14* of the warp feeler must rest on the warp yarn wound on the weaver's beam. When the weaver's beam is empty, and the feeler foot rests on the beam pipe, the link roller *4* must not fall out from the link slots and must be 4-5 mm above the bottom slots. The pawls *3* and *2* of the bottom link must be disposed on the ratchet feet over all their width

so that one pawl butts against the tooth and the second is in the middle of the adjacent tooth.

The bottom link is adjusted in working position with the slay in extreme front position and the warp released. The link is adjusted so that it butts with its upper arm against the limiter arranged in the bottom part of the left-hand frame. At this, the eyelet *20* is rigidly connected with the drawbar *21* leaving a clearance of 2-3 mm between the interior surface of the eyelet slit and the exterior surface of the finger *19*. Next, the slay is shifted in extreme back position at which the finger *19* must easily and freely move in the eyelet slit and the eyelet must shift in the direction of slay sword movement only under the action of the back rest *11*. The drawbar *21* and eyelet *20* must not contact the roller *17*.

For increasing the warp tension the springs *8* and *7* are clamped by the nuts *16*. Rarely the warp tension is increased by shifting over the back rest *11* in the seats of the bracket *10* in the direction of the shaft *12* or also the drawbar *9* in the extreme right-hand hole of the pressure lever *13*. The tension of springs *8* and *7* is checked by pressing with the hands on the back rest; when the pressure is released, the link and leverage system of the regulator must return into initial position. The angle between the pressure angle *13* and the drawbar *9* must be equal to 90° and the warp beam rod must freely rotate in bearings without longitudinal shift. The longitudinal shift of the back rest should not exceed 2 mm.

In the course of operation the following disarrangement may occur: wear of the ratchet teeth and pawl working surfaces; pawl breakage; oil penetration on the brake pulley; wear of the leather on both braking blocks; thread deterioration on both end nuts. The worn-out parts are repaired or replaced by new ones.

Worm-type warp let-off motion. In this kind of motion the planet-type mechanism is replaced by a worm couple, which is simple in design, reliable in operation and easy to adjust. The instructions for the adjustment of the worm-type warp let-off motion are the same as those for the planet type motion, because the process of warp yarn let-off and tensioning remains unchanged.

Warp delivery motion in pneumatic looms. The initial warp tension is created by the force of the spring *6* (Fig. 145) which may be adjusted by the nuts *10*. The force of the springs *6* must be the same from both sides, as otherwise the back rest will misaligned which will affect the loom operation.

To ensure the normal operation of the warp tension and let-off motion the initial clearance between the head of the adjusting bolt *5* and the finger must not exceed 8 mm. By turning the nuts *10* actuating the spring *6* through the intermediate of the screw *8* and the rest *9* it is possible to adjust the warp tension during machine running. To obtain a smooth operation of the motion provided on

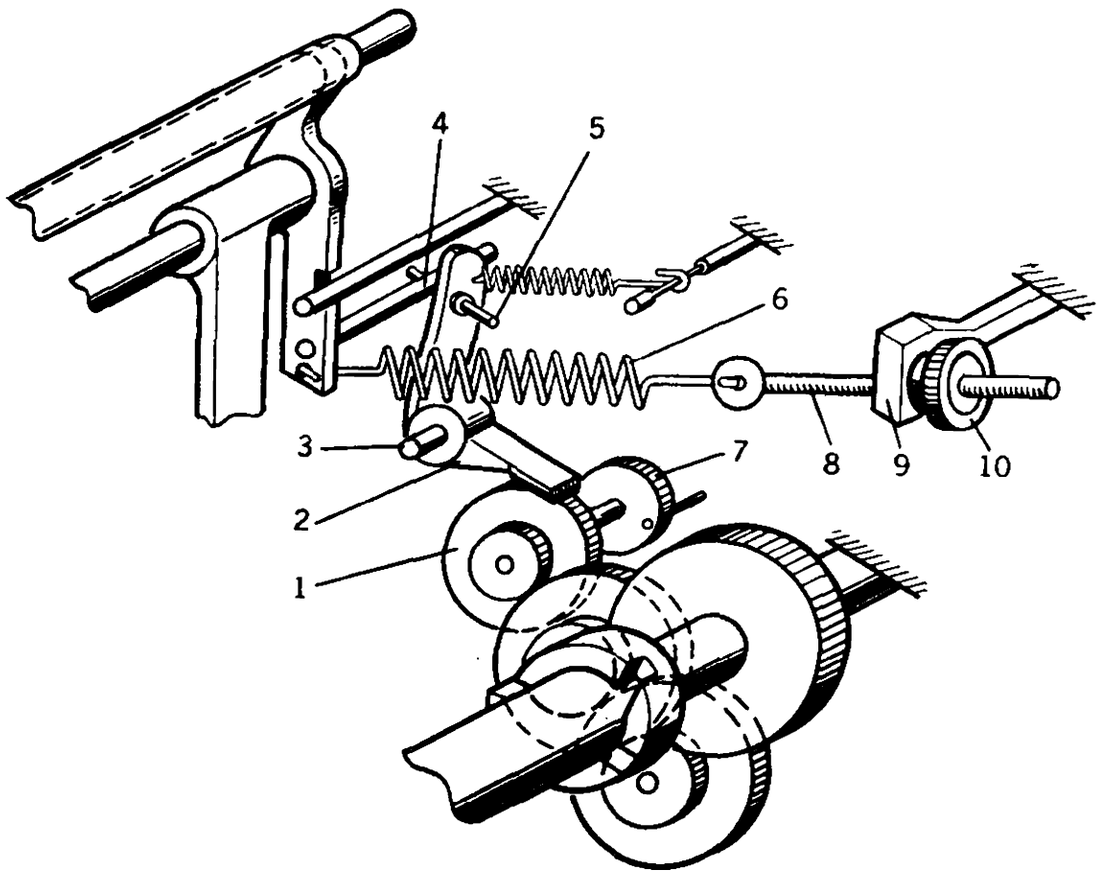

Fig. 145. Warp tension and let-off motion in a pneumatic loom

the shaft from the exterior side of the frame are inertia disks *7* with a mass ensuring slight slippage of the braking block at the time of braking. The disks have a crank for turning the weaver's beams by hand.

In the warp delivery motion the most liable parts subject to wear are the gear shafts, the braking wheel *1*, the adjusting bolt *5*, the brake block *2* and the shaft *3*. The mechanism parts which have been removed during disassembly should be washed and cleaned from fluff and dirt (especially the gear toothing). All the other parts are replaced when they are worn out. The glueing of plugs on the brake block is facilitated by a simple arrangement. The brake blocks are fitted on a rod and a metal plate is pressed above by wing nuts leaving them in this position for 15-20 hours until the glue has completely dried.

The cloth take-up motion of the СТБ shuttleless and АТПР rapier looms. This take-up motion is of the positive type. At the time of repairs, the take-up motion is disassembled and worn-out parts are replaced by new ones, or restored. Due to the difficult rotation of parts in the bearings or to gears tightly connected with each other, thick places may appear on the produced fabric. In this case, the take-up motion is disassembled, worn-out parts are replaced and using a handwheel the take-up motion is checked for easy running. If

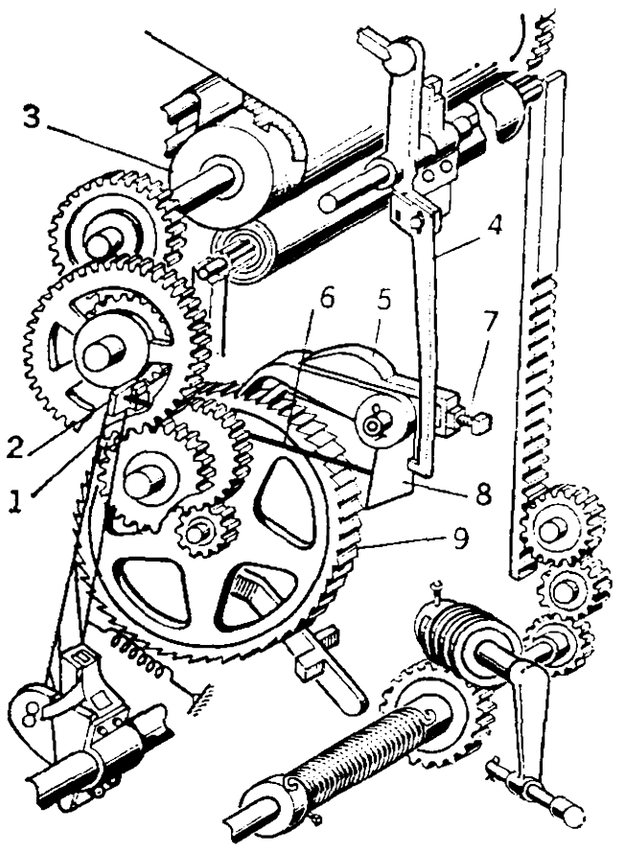

Fig. 146. Take-up motion in AT loom

the motion turns easily without jamming it means that the cloth take-up motion is properly operating.

The cloth take-up motion of a shuttle loom. The proper adjustment of the cloth take-up motion is checked as described below. The take-up roller *3* (Fig. 146) must be easily turned by hand and its axial shift must not exceed 1 mm. There must be an equal clearance over the entire length between the take-up roller and the breast beam. The meshing of gears must be such that ensures a clearance of 1 mm between the tooth head of one gear and the tooth cavity of the other gear; all the gears must be properly engaged in teeth width and must easily rotate. The pawl must engage the ratchet over the full width of the teeth, as otherwise the ratchet and pawl teeth will prematurely be worn-out. The proper engagement of the slide block *2* and ratchet is achieved by turning the bushing on which the take-up drawbar *1* is mounted with a clearance not over 1 mm. When the slay is in back position, the distance from the slide block *2* to the tooth of the ratchet *9* must be 5-8 mm. This distance is adjusted by shifting the lever *4* and modifying the length of the rod *6*. The amount of fabric let-back is adjusted with the bolt *7* by increasing or reducing the free stroke of the mispick control pawl *5*. When the slay is in rear position the clearance between the end of lever *4* and arm *8* must be equal to 3 mm. The same clearance is set between the right-hand end of the rod *6* and arm *8*.

The main kinds of disarrangements are: fixture slackening, wear of take-up roller bearings, wear of the slide block *2*, gear toothing, pawls and ratchets. As the take-up motion is repaired, worn-out parts are replaced by new ones.

The wind-up motion of pneumatic looms. This motion is intended for winding the produced fabric on the cloth roller. At the time of repair, the take-up roller mechanism is disassembled to get the worn-out parts replaced. Disassembling is started by turning off the nuts of the screws *3* (Fig. 147). Next, the bearings *2* are lifted, the pressure roller with coating *5* is extracted, the screws *6* are turned out, the bushing *12* is shifted to the right, the left-hand pin is removed from

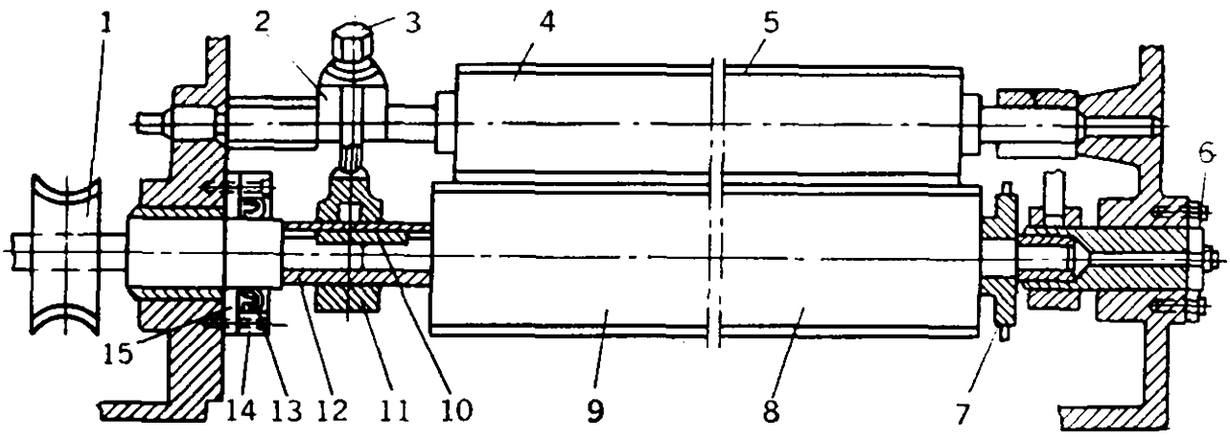

Fig. 147. Diagram of take-up and pressure rollers in a pneumatic loom

the bush as well as the take-up roller *8* with the disk *7*, and the bushing *12* with the key *10* is taken off.

If a complete disassembly is necessary, the screws *14* are turned out, the cover *15* with the packing ring *13* is taken-off and the worm gear *1* with the shaft is extracted from the recess. The screw *3* is turned into the eyelet *11*. After complete disassembly, the parts must be washed and worn-out parts are to be replaced or restored.

Most frequently it is necessary to completely replace the grater *9* and partially the technical felt. After removing the grater, the take-up roller is cleaned and a new grater is wound bearing in mind that the cut on the grater may be straight and inclined. If the cut is straight, winding may be started from any side of the take-up roller, but if the cut is oblique, the pointed part of the cut must be directed in the sense of movement as otherwise the fabric will slip on the surface of the grater. The right-hand side of the take-up roller may be wound over a length of 200-300 mm with one or two layers of fabric (above the grater) to avoid clogging of the grater with weft threads from the fringe. The grater must be tightly and smoothly tensioned on the take-up roller and must be attached from both sides with screws or nails, for which purpose end wooden plugs are provided on the take-up roller.

Technical felt on the pressure roller *4* is rarely worn out over its whole surface and most frequently its right-hand side is worn out and replaced. To ensure a better fastening of the felt on the roller, a complementary winding of one or two fabric layers may be made and impregnated with joiner's glue. To avoid folds a whole piece of technical felt should not be wound on the pressure roller. The felt should be cut in strips 80 mm wide and 5400 mm long.

During the operation of the cloth roller friction clutch, the spiral spring bent ends might become broken and the tension roller and its shaft worn. Worn-out parts are replaced by new ones.

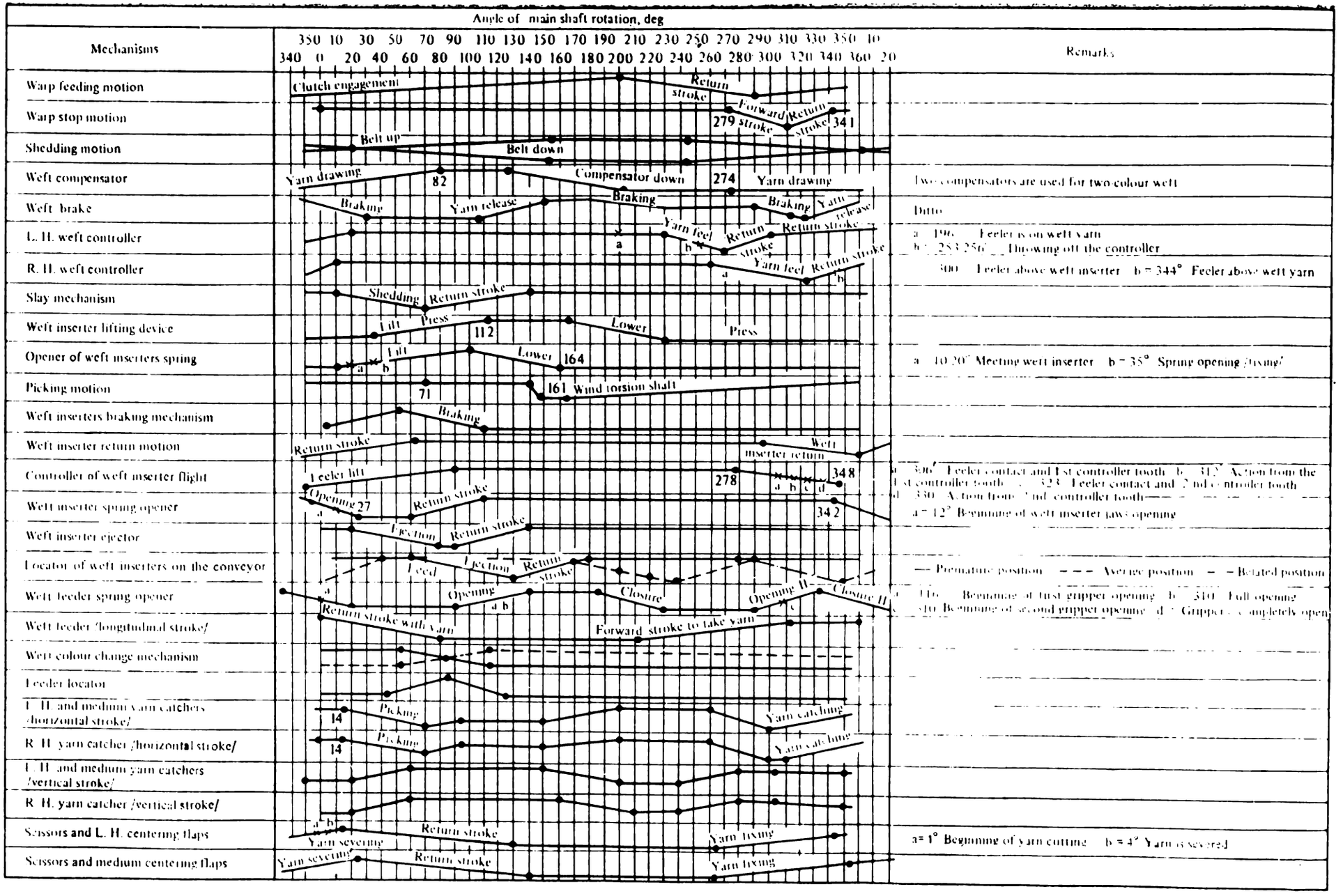

Fig. 148. Cyclograms of the operation of looms СТБ-216, СТБ2-216, СТБ2-175. Figures 175 and 216 mean the gaiting width in cm; figure 2 indicates the presence of a multicolour weft mechanism

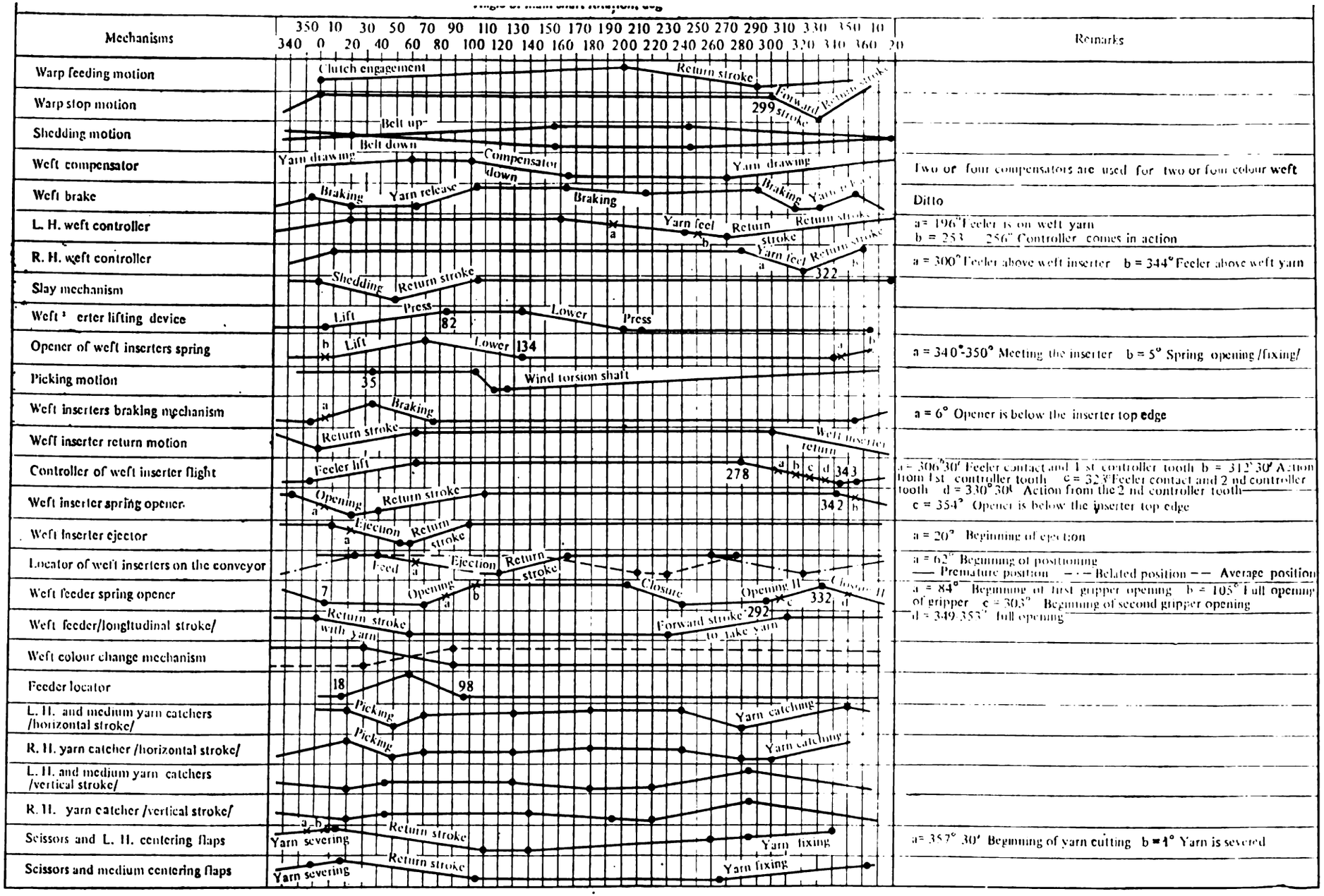

Fig. 149. Cyclograms of the operation of looms СТБ2-330 and СТБ4-330. Figure 330 means the gaiting width in cm; figures 2 and 4 indicate the presence of a multicolour weft mechanism

Cyclograms of Loom Operation

The normal work of looms is possible only when the operation of all mechanisms and devices is strictly timed. It means that the beginning and end of all operations of mechanisms, devices and parts must take place at certain moments which are correlated with the action of the loom, as a whole.

The loom adjustment may most easily be discussed by correlating the action of its mechanisms with only one unit the operation of which is strictly determined and does not depend on the operation of all other mechanisms and devices. Such a working unit is the loom main shaft, one revolution of which corresponds to the loom working period, i.e. to the period when one fabric element is formed. The circumference corresponding to one revolution of the main shaft is divided by 360°, and the extreme front position of the reed is adopted as the beginning of motion, i.e. the moment of weft beating-up to the fabric felt. Expressing the beginning, duration and end of loom mechanism action by means of the main shaft angle of rotation, we obtain a cyclogram of loom operation.

For the correct and reliable operation of the loom the precise interaction of its individual parts and mechanisms is essential. For this, zero match marks are used which must coincide at the time of assembly. The mark on the cam side face must be set opposite the zero match mark on the shaft. To check the operation of separate parts and mechanisms of the loom, their proper assembly during erection and repair, and work interaction of any mechanism,

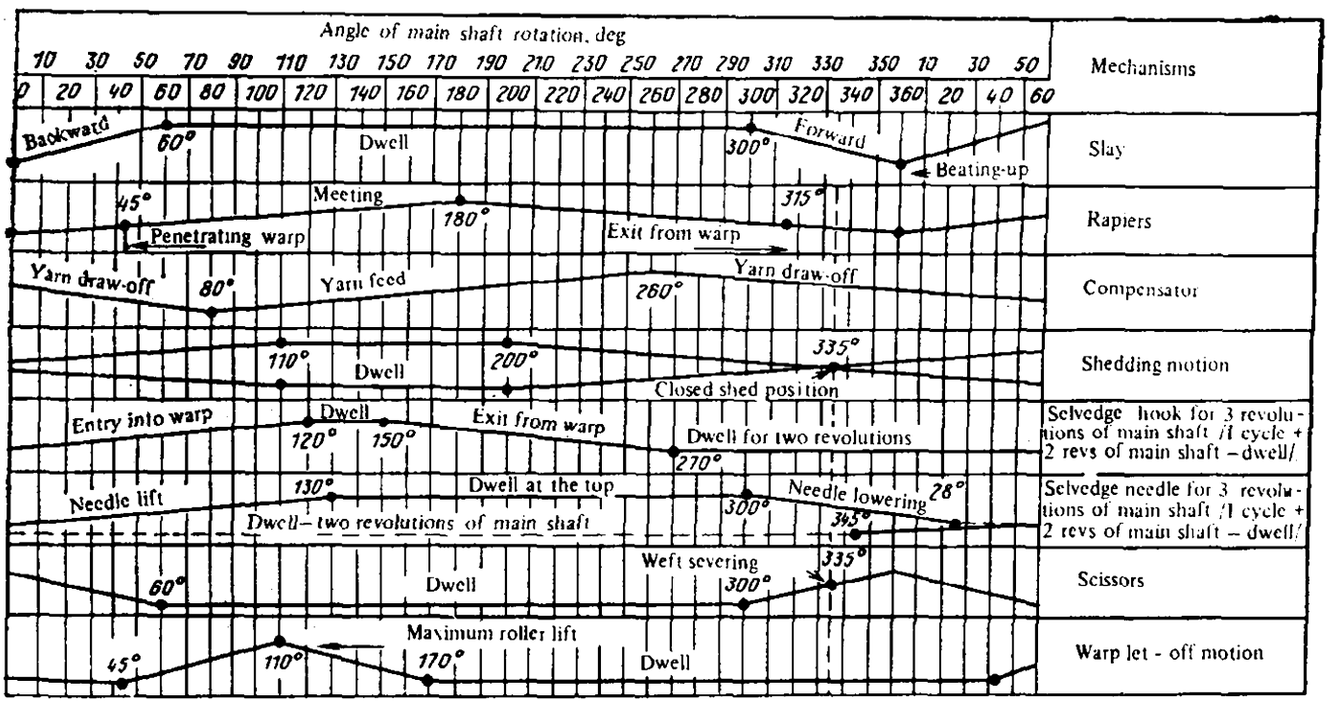

Fig. 150. Cyclograms of the operation of looms АТПР-100 and АТПР-120. Figures 100, 120 indicate the gaiting width in cm

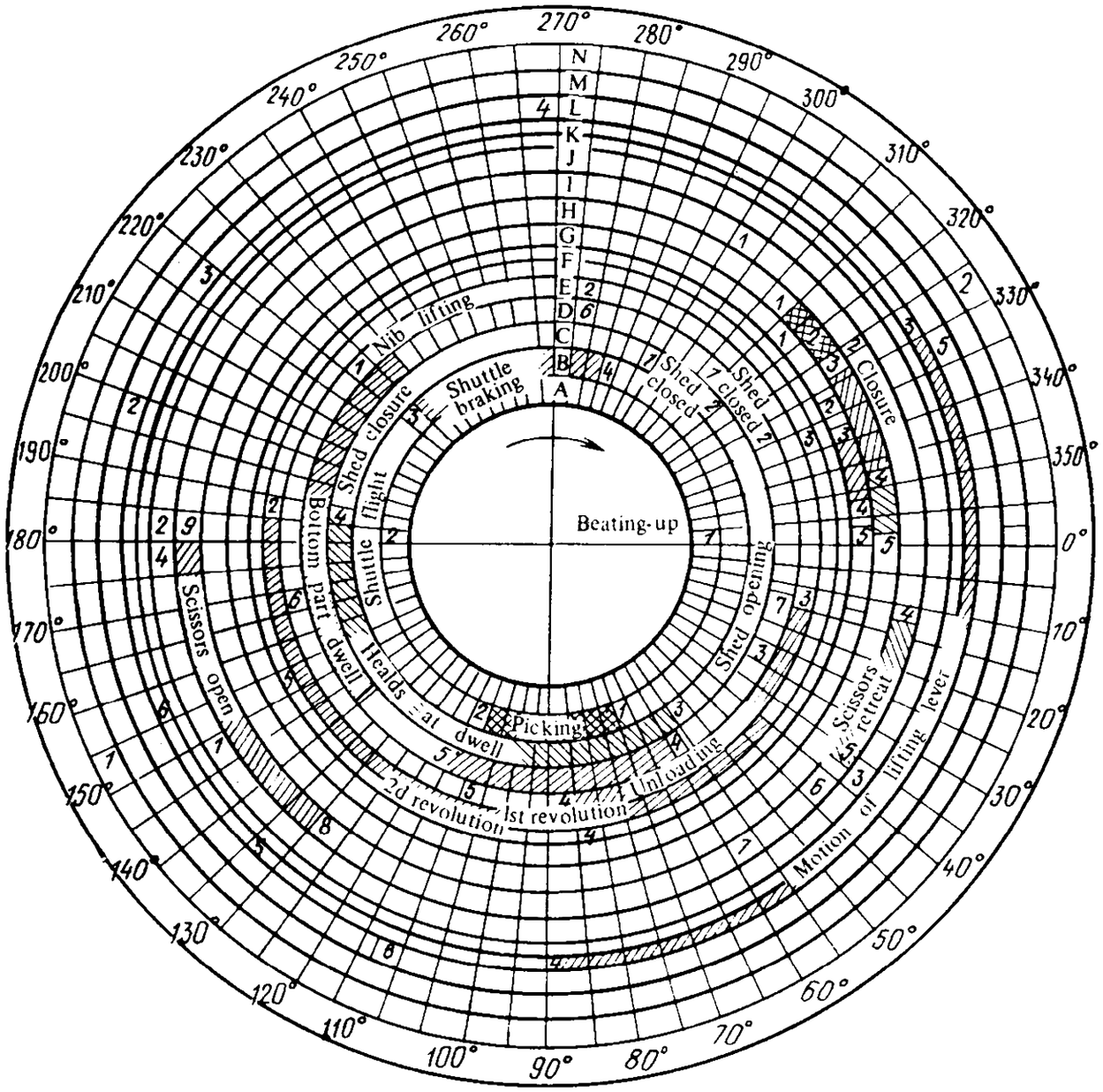

Fig. 151. Cyclogram of the interaction of mechanisms in the loom AT-100-5M. Figure 100 means the gaiting width in cm

cyclograms should be drawn up showing the operation of the loom mechanisms. Using these cyclograms and the scale provided on the braking handwheel, an adjustment is made for setting the beginning of operation, dwell, and the completion of work of one or another mechanism (Figs. 148-151). No deviations in the operation of mechanisms from the established parameters of the cyclogram are allowed.

As is known to compile a cyclogram for a shuttle loom, the front slay position (0°) is taken to be the beginning of slay motion counted in degrees of the main shaft rotation angle. In shuttleless СТБ looms the count is started at the moment of slay displacement from the back position (0°). Therefore when comparing the action of separate mechanisms in shuttle and shuttleless looms, it is necessary to bring

in coincidence the main shaft zero position with the main shaft position at 70° in shuttle looms and 50° in shuttleless looms.

To facilitate the timing of mechanisms in pneumatic looms, use is made of a circular diagram arranged on the main shaft and having the following designations: 0°—beating-up position; 15°—beginning of yarn guide motion; 65-75°—beginning of pick pressure foot retreat; 90°—top position of catching tooth; 95-105°—beginning of air supply into the nozzle; 125-130°—ejection of the pick from the catching tooth; 300-340°—cutting the pick with left-hand blades; 350°—extreme top position of small lease rod.

REVIEW QUESTIONS

1. Discuss the classification of looms.
2. Name the types of repairs for looms. What is their essence?
3. Discuss the repair of frames, ties and breast beam of the loom.
4. How is the drive of the СТБ shuttleless looms adjusted?
5. How are the repairs of a shuttle loom drives carried out?
6. What are the parts of a pneumatic loom which are subjected to hard wear and how are they restored?
7. Discuss the adjustment of the tappet shedding motion in the СТБ shuttleless looms.
8. How is the repair of a tappet shedding motion done on a pneumatic loom?
9. How are the tappets repaired and what are peculiar features of this kind of repairs?
10. How is the repair of knife dobbies done?
11. How is the picking box of the СТБ shuttleless loom adjusted?
12. How are small-size weft inserters repaired?
13. How is the picking motion of the СТБ shuttleless loom adjusted and repaired?
14. How is the picking motion of a shuttle loom adjusted?
15. How is the supply and distribution system of compressed air in pneumatic looms repaired?
16. How is the weft insertion mechanism in the АТПР rapier looms adjusted?
17. How is the air duct system in АТПР rapier loom checked?
18. Describe the preventive inspection and repairs of the rapier drive.
19. Discuss the adjustment of the slay mechanism in the СТБ shuttleless loom.
20. How is the slay mechanism of a shuttle loom adjusted?
21. How is the slay mechanism of a pneumatic loom adjusted and repaired?
22. How is the warp protector motion of a shuttle loom adjusted and repaired?

23. Discuss the methods of repairing the warp delivery motion in the СТБ shuttleless loom.

24. What is the essence of the adjustment of a planet-type regulator in a shuttle loom?

25. How are the tension and warp let-off motions of a pneumatic loom repaired?

26. How is the take-up motion of a shuttle loom adjusted?

27. How is the take-up motion of a pneumatic loom repaired and adjusted? What are their peculiar features?

28. Explain what the cyclogram of the loom operation is.

29. What is the main difference between the cyclograms for shuttle and shuttleless looms?

30. Using a loom cyclogram explain the essential moments in the operation of separate mechanisms.

CHAPTER 7

METHODS AND KINDS OF REPAIRS OF TEXTILE EQUIPMENT

1. Methods of Textile Machinery Repairs

The repair methods employed determine the procedures carried out during the restoration of textile machinery. There are two main kinds of repair methods: the individual repair method and the unit repair method.

The individual method of repair is a procedure when parts and units removed from the machine for repair are mounted on the same machine after repair (with the exception of those parts and units which are worn out and have to be replaced by new ones). This method presents the following disadvantages: lengthy idle time, high cost and low quality of repairs. With individual repairs, parts are repaired and manufactured on a separate basis, the machine assembly and adjustment after repair is a difficult and complicated operation and takes a great deal of time and effort; the mechanization of repair is hard to achieve because the design dimensions of machine units and joints are changed; no interchangeability of parts is possible. The individual method of repair is presently used only for huge and nonstandard machines.

The unit repair method is that at which preliminarily prepared, adjusted, and tested new or repaired units and parts are installed on the machine instead of the removed units and parts. The dismantled parts and units are sent to specialized workshops for processing and repairs. In the case of the unit repair method, the idle time is shorter than at individual repair, the cost of repair is lower and its quality higher. There is no idle time due to the absence of units and parts as the repair and manufacture of parts and units are made in advance and with partial interchange; for mounting the parts and units inconsiderable machine adjustment is required and the repair operations may largely be mechanized.

The unit repair method is most efficacious in the case when the equipment is of the same type and when the main units of the machines manufactured by different machine-building plants and of different models are unified. If the equipment is of different types and its basic units are not unified, the repair method by unit is rendered difficult as a great reserve of different units and parts must be kept

in stock. The parts cannot be interchanged so that a careful adjustment must be carried out. Therefore in these cases the repair method by unit involves only the preparation of requisite units in advance.

The in-line unit repair method comprises the restoration, mating and working-in of the most labour-consuming units and mechanisms in workshops equipped with special machines, stands and fixtures. In these special workshops the repairs are carried out in-line, thus ensuring their high efficiency and good quality. The repair teams in this case have only to mount the units on the machines to be repaired and to proceed to their adjustment.

The duration of unit repairs that find application in the textile industry may be of one shift and two shifts; and may be carried out on stands and by sections.

With *one-shift repair method*, the machine s repaired only by one team of workers during one shift (usually, the first shift) independently of the shifts in the main production departments. Repairs during one shift involve the longest downtime, though the duration of repair may be short. This kind of repair may be used for machines of any purpose and design. With *repairs during two shifts* an enlarged team is divided in two subteams; each subteam would repair the machine continuously during the first and second shifts. The duration of repair remains the same, but the machine idle time is twice less as compared with the idle time involved in one-shift repair. With *stand repair* the machine is removed from the base and transported to the repair platform or into the repair shop where all the necessary operations are carried out on a specially equipped stand. A reserve machine is installed instead, and the repaired machine is sent for keeping in reserve. The idle time of the machine in repair does not practically affect the production capacity of the department, as the working post remains idle only during the time which is necessary to remove the old machine and to install the new one. Stand repair is mainly carried out in the case of looms.

With *by-section repair* separate large parts or sections are repaired in consecutive order. The repairs are carried out during nonworking days and shifts (usually, during days-off); and in the periods between these days and shifts the machine continues to work. The main advantage of the by-section method of repair is that there is no idle time during the working hours. When repairing separate sections, the scope of work to be done should be chosen so that it can be fulfilled in the course of a day-off, and the machine after repair may be prepared for operation for the next work shift. The by-section repair may prove more time-consuming than any other type of repair as it is necessary to disassemble the preliminarily repaired sections or units for their adjustment and mating with those section and units which have been repaired during the given day-off. The by-section repair method requires the especially careful preparation

of parts, units, materials, tools, devices, etc., good organization of work, and is used mainly for those machines which are not numerous at the enterprise, and their stoppage for repair during working days may interfere with the work of the enterprise (for instance, opening ranges, cards and sizing machines).

2. Purpose and Structure of the Repair Service in the Textile Enterprises

The repair service in textile enterprises operates according to the system of scheduled preventive repairs comprising preventive technical measures, the maintenance and inspection of equipment. Thus, the system of scheduled preventive repairs includes the technical maintenance, current, medium and overhaul repairs of textile machinery.

Technical maintenance comprises cleaning and oiling of machines, elimination of small disarrangements, adjustment of units and mechanisms.

Current repairs provide for the elimination of small disarrangements, the adjustment of units and mechanisms, and the repair of rapidly wearing parts and units according to schedule.

With *medium repairs* the machine is partially disassembled, the worn-out parts are replaced, the units and the machine as a whole are inspected and adjusted (see the list for the medium repair of СТБ shuttleless looms in the Appendix).

The overhaul repair comprises full disassembly of the machine, replacement of all the parts, assembly, checking and adjustment of all units and mechanisms.

The duration of periods and cycles between repairs for the equipment in different fields of the textile industry is established depending on the kind of machines and the working conditions. In most cases, at three shift work the periodicity of medium repairs is from 3 to 6 months, and that of overhauls from 2 to 3 years.

The repair service at textile enterprises carries out not only the repair of equipment, but also its modernization, erection, manufacture of new parts, and the restoration of worn and broken parts, and executes the orders of the maintenance service for keeping the equipment in good working condition.

The repair service at a textile enterprise comprises central repair workshop and mechanical repair department workshop. Central repair workshops are organized at integrated mills and large enterprises with several production departments. At small enterprises repairs and the maintenance of machinery in different departments of the enterprise are carried out by mechanical repair workshop.

The main purpose of the central repair workshop is to supply nonstandard spare parts for the main and complementary textile equipment operating at the enterprise. All standard and some nonstandard (difficult to manufacture) parts of the technological equipment are supplied to the enterprise through centralized cooperation with plants producing these spare parts.

The central repair workshop repairs intershop (interfactory) service lines, intershop transport and power equipment, and is responsible for the modernization of equipment, mechanization of labour-consuming processes, the introduction of new techniques, rationalization and inventions.

Textile enterprises are equipped with various machines of Soviet and foreign make different in design, precision, and finish of their parts. The requirements set towards the service life of machine parts demand use of stronger materials. Moreover, the manufacture of textile goods requires the use of a great number of technological equipment and machines at an enterprise. This means that thousands of different spare parts must be available at a textile enterprise.

3. Repair Shops in Spinning Mills

The central repair workshops of large textile enterprises are producing new, nonstandard and spare parts, while the repair workshops of smaller enterprises repair and restore units and parts, and manufacture the simplest special-purpose parts. The repair workshops of most enterprises may be subdivided into general-purpose and specialized repair workshops. In general purpose workshops various jobs relating to the production and repair of parts are carried out, while in specialized shops a limited number of units and parts are restored and repaired (they are frequently called unit repair workshops). Fig. 152 illustrates the structure of a repair workshop in a cotton spinning mill.

Repair workshops make use of versatile equipment and tools mainly. The system of multipurpose assembly devices is designed to assemble equipment for metal-cutting machine tools exclusively from standard parts. Owing to the efficacious choice of the part design and of the materials and thermal treatment employed for their manufacture it is possible to create convertible devices allowing a multiple use of standard parts. The parts of the versatile assembly devices run the following course of closed cycle: storage of parts—assembly of devices—use of devices—disassembly of devices—storage of standard parts—assembly of devices (of another design), and so on. The basic parts of versatile assembly devices (plates, angles, supports, straps, and so on) are manufactured of high-alloy steels, heat-treated, and have a high wear resistance and strength so as to serve on the average not less than five years. Devices are

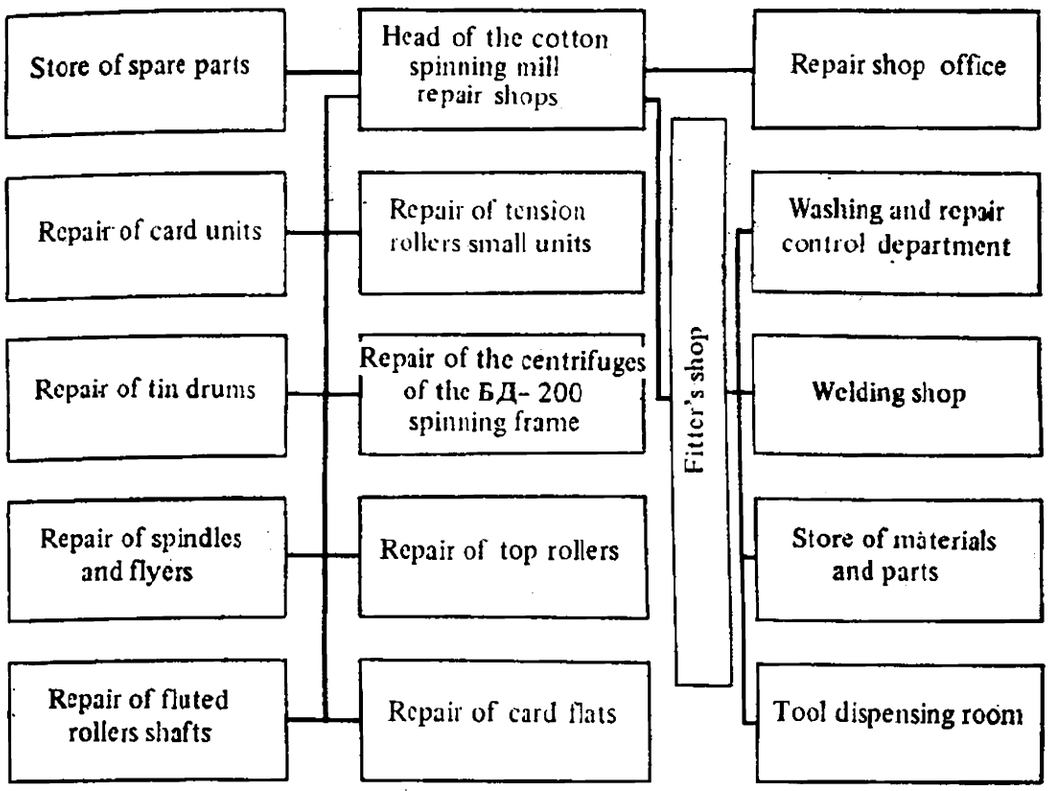
Store of spare parts
Head of the cotton spinning mill repair shops
Repair shop office
Repair of card units
Repair of tension rollers small units
Washing and repair control department
Repair of tin drums
Repair of the centrifuges of the БД- 200 spinning frame
Fitter's shop
Welding shop
Repair of spindles and flyers
Repair of top rollers
Store of materials and parts
Repair of fluted rollers shafts
Repair of card flats
Tool dispensing room

Fig. 152. The composition of repair workshops in a spinning mill

assembled from such elements practically obviating the stage of design and the process of part manufacture from metal. For instance, versatile assembly devices are used for drilling, milling, grinding, and turning.

During assembly, it is necessary to have a drawing of the part and the description of technological process indicating the sequence of operations, and also the blank of the part. Technological charts are essential for assembly fitters to follow the sequence of operations and choose the proper processes. The precision of part processing using the versatile assembly devices is dependent on two factors: the precision with which the parts of the versatile assembly devices have been manufactured and the adjustment of the device dimensions by the fitter. As a rule, all the parts of the versatile assembly devices have a high class of precision, so that the deviation of two slots in a plate from the nominal value is to be within $\pm$ (0.01-0.02) mm. The deviations in the parallelism and perpendicularity are approximately the same. On combining several parts in one device, the parts are chosen with positive and negative allowances and the total deviation in the dimensions of parts used in the device does not exceed 0.01 mm. This is achieved by adequate choice of parts and by the use of measuring plates for assembling the versatile assembly devices, so as to obtain parts with a finish of second and third classes of accuracy.

General Purpose Repair Workshops

The composition of general purpose repair workshops is almost the same for all enterprises in different fields of the textile industry.

The fitting shop. This shop deals with repair and manufacture of most different parts. For this reason, the technological process is based on the production of separate parts by versatile equipment. All the jobs connected with the restoration of machine spare parts are carried-out on orders received from the repair workshops and operating personnel. In some enterprises separate parts are manufactured according to quaterly or monthly requisitions. The establishment and employment of standard process charts for the restoration of standard parts ensures better quality and lower cost of machine repairs.

The washing and defect locating department. Worn-out and broken parts which have been removed from machines sent for repairs have their surfaces coated with lubricant, dust, and fluff, showing the traces of wear and corrosion. This renders difficult the location of defects, impairs the quality of repair and labour conditions. Hard dirt particles are eliminated by scraper and metal brushes. To remove fluff, dust and unhardened lubricants the parts are washed in ordinary alkali baths which are cheap and fire-safe. Good quality and high efficiency of part degreasing are obtained through the employment of ultrasonic baths.

Cleaned and degreased parts are checked for defects at testing posts equipped with instruments, repair templates and gauges. Thus, ball bearings are inspected by means of a special instrument, and the gear tooth thickness, by a repair gauge. The run-out of spindle blades, axles and other cylindrical parts is determined by means of a setting prism and indicator. The interior defects (cracks and cavities) are detected by means of ultrasound and magnetic-field flaw detectors. For storing during a lengthy time the most important parts (such as ball bearings, chains, etc.) are coated with slushing compounds.

The welding department. In the welding department, worn-out and broken parts are restored by electric arc d.c. and a.c. welding units. Practical experience in many enterprises has shown that for better welding the department must be equipped with the following machines and units: a movable welding transformer for a.c. welding or a d.c. welding rectifier, a welding post, a fitter's bench, a roughing and tool grinding machine with flexible shaft and a rack for storing materials, tools, and parts. In repair departments of large enterprises it is efficacious to provide a unit for dip transfer surfacing of worn-out shafts and fluted cylinders.

The tool dispersing room. This room serves for keeping materials and restored parts prior to their sending to the shop store. High-

precision instruments and tools are kept in the tool dispensing room of the central repair workshop from which they are received when necessary for temporary use in the departmental repair workshops.

Specialized Repair Workshops

The repair of spinning machine units is rather time-consuming. This is explained not only by the great number and the complicated unit design, but also by the need of their repair either directly at the machine, or in a fitter's shop. It is good practice to release the repair teams from this job and to pass this work to a special staff of fitters working in a specialized workshop. In this way, repair is made less laborious, its quality improves and the idle time of machines during repair is reduced because of replacing the units from the machine sent for repair by other units which have been preliminarily repaired and run-in.

The card repair workshop. The design of cards is convenient for repair by units. The most complicated units requiring labour-consuming repair may be removed from the card and transported to a special workshop usually consisting of two departments—the flat repair department and the department repairing all other units.

Flat repair departments are available in all cotton spinning mills equipped with cards. The following operations are carried out at the time of repair of flats in the workshop: cleaning the needle fillet from dust and fluff; wiping the grid bars with rags; sorting out flats to determine the wear of the needle fillet; straightening bent grid bars; removing the worn-out needle fillet and covering grid bars with a new fillet; restoring seats; grinding flat needles, and inspection.

The department is equipped with a machine for removing fluff and dust from the carding fillet, with fillet grinders, and a machine for stripping and covering with carding fillet. The machine production speed in flat coating stripping is 40 flats per hour. If the grid bars are slightly bent they are straightened in a screw press.

The quality of carded cotton sliver may be strongly affected by the wear of grid bars, which is eliminated by metal building-up or by coating with styracryl with subsequent milling or grinding the recesses.

There has been established a process for repairing the bearing surfaces of card flats and for levelling the base of flat grid bars by using polymer materials. Here, the life of repaired grid bars is three or four times that of new ones, moreover these grid bars allow the use of modern semirigid and rigid fillets that require no grinding due to which quality of the card fillet rises. A specialized production department (the equipment lay-out in this department is shown in Fig. 153) has been created for the repair and straightening of flat grid bars with polymer materials, and a polymer composition using

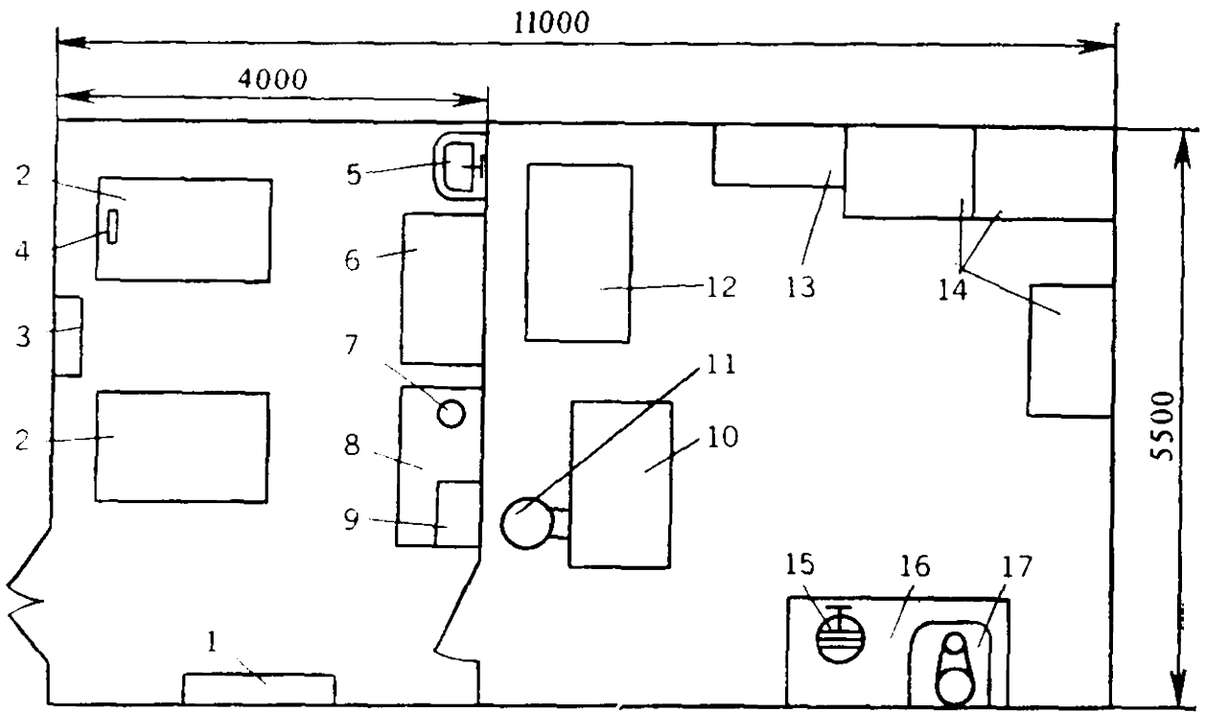

Fig. 153. Diagram of flat grid bars repair shop

1—checking rule; *2*—surface plates; *3*—automatic system for plate electric heating; *4*—thermometer; *5*—washstand with hot and cold water; *6*—polymer storage cabinet; *8*—bench with exhaust cabinet *9* and electric stove *7* for preparing polymer composition; *10*—machine for preparing seatings for coating; *11*—plenum-exhaust ventilation; *12*—machine for cleaning the base of grid bars for coating; *13*—locket for working clothes; *14*—racks; *16*—bench with vice *15* with table drilling machine *17*

epoxy resin. The quality of flat grinding is checked by stationary indicators.

Special departments for the repair of other card units are organized at enterprises where the number of cards is more than 300. The repair of combing boxes, licker-in units, speed boxes, doffer couplings, combs, licker-in reducers, feeding arrangement and drive of flats is most efficient in workshops equipped with special devices ensuring, rather than on cards themselves.

In the course of operation, the following disarrangements frequently occur in the comb box: the wear and breakage of glands, oil leakage, wear of the shackle, sector and cam shafts. In the licker-in unit the whole-metal saw-toothed fillet becomes blunt and destroyed, and the ball bearing clogged and worn-out. The main defect observed in the speed box is the wear of the lead-gear spindle, gears, and bearings. In the reducer of the licker-in, the reducer shaft bearings, and toothed gearings are worn-out. In the flats feed and drive reducers the worm shaft is frequently jammed and broken due to the clogging of lubrication ports. Burrs appear on the doffing combs and the needles are broken.

The repair of machine units is accelerated by employing different devices. A device has been designed for the rapid pressing-in of bushes and rollers into the hubs of pulleys and sprocket gears. The

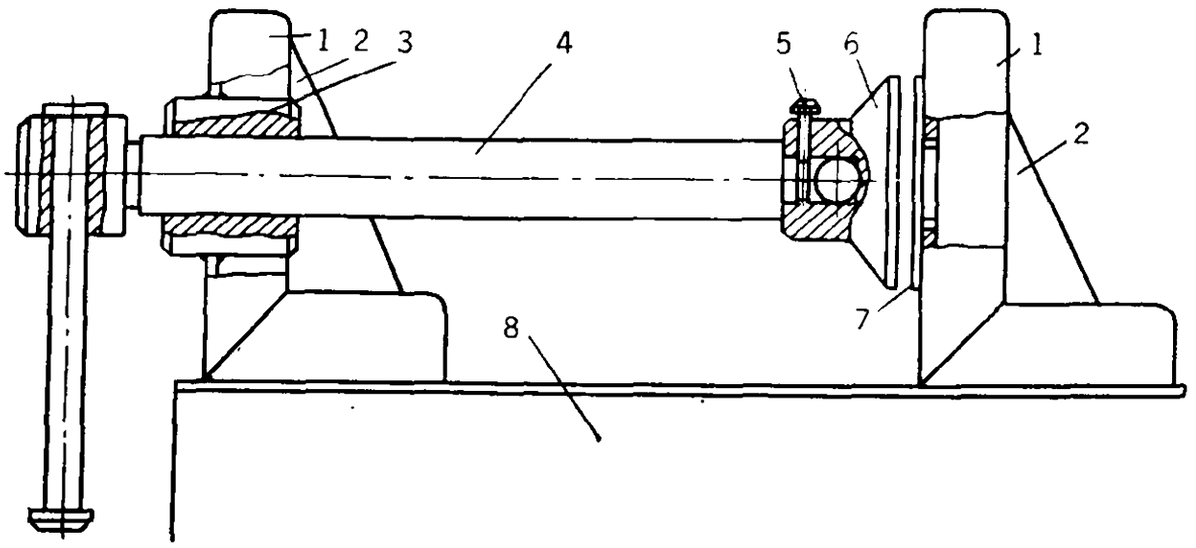

Fig. 154. Device for press-fitting of bushings and rollers in hubs of pulleys, gears and sprockets

device (Fig. 154) consists of two stands *1* with welded-on four ribs *2* (for reinforcing the rigidity of stands made of channel 124), the nut *3* rigidly fixed in the stand, the screw *4* with a small pitch $z = 4$ mm and with a diameter of 40 mm for progressive pressing-in and -out of the cone of thrust bearing *6* (which freely rotates on a 20 mm diameter ball) and of the stop-screw for allowing the bearing to freely rotate at the end of the screw without slipping down during the operation. The device is rigidly fixed to the bench *8*. In pressing-in and -out the bushings with different diameters, flange inserts *7* with inside holes of different diameters are used, and in pressing-out the rollers from pulleys and gears—steel fingers of various diameter.

When pressing-in a bush into a gear, a flanged insert of adequate diameter and without interior hole is chosen and is inserted in the aperture of the ribbed stand. Next the gear is placed so as to make its interior hole coincide with the thrust bearing centre. Turning the crank the worm is put in motion and by the intermediate of the thrust bearing it presses in the bushing into the gear. Pressing-out is done in the same way, the only difference being that the flanged insert is chosen with a hole of adequate diameter. This device facilitates the work of turners, reduces the time necessary for the replacement of bearings and protects the hubs from premature wear.

The slotting of interior key-ways in gears of big diameter (up to 1000 mm) may be carried-out by means of a special device. A lathe chuck is attached with three bolts on a special angle which has its other surface attached on the table of a planer by means of two bolts with the vice removed. The gear to be machined is attached in the lathe chuck by cams on the exterior diameter of the column. The mandrel with the cutter passes through the interior hole of the chuck and effects slotting.

Comb repair shop. Such shops are available in flax and woollen spinning mills, for repairing the needle fillets of cards, drawing and roving frames and scutchers, blenders, spreading machines, and beamers. In the flax spinning mills the needle plates are repaired by replacing broken needles, eliminating hooks on the needle ends and dressing the combs and plates. In combers new needles are soldered to the plates and set in the drums. For removing the combs from the plates of a drawing frame an eccentric manual or a mechanical press is used to shear the rivets. Different gripping and other devices are employed for repairing combs. Straightening is effected on fitter's benches. Blunt needles and bent needle ends are restored by a honing stick and more rarely by electric polishing.

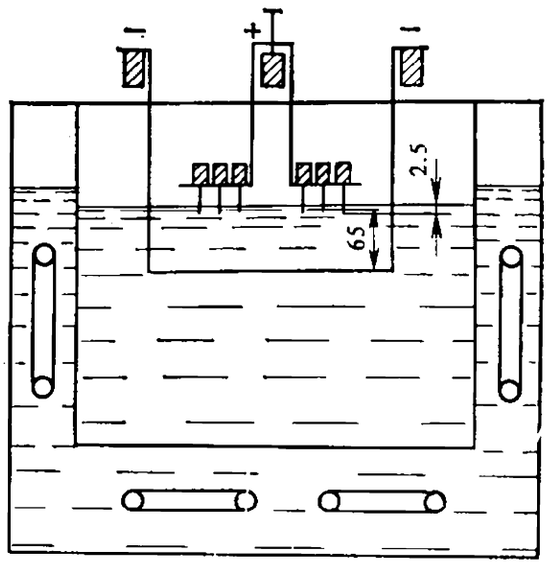

Fig. 155. Diagram of unit for restoring needle fillets by electropolishing

Electric polishing makes the needles sharper and improves the class of roughness (up to 0.63) owing to which the produced fibre is of higher linear density. The bath for electric polishing (Fig. 155) is installed either in the electroplating or comb shop. The bath dimensions correspond to the maximum size of comb plates. This process is carried out with high speed as several combs may be simultaneously charged into the bath and the time of electropolishing does not exceed 2.5 min.

Depending on the method of their fixing broken needles are removed by pressing-out, unsoldering or by heating and removing all the fillets on the plastic base from the plate. The holes in wooden plates are drilled in a table top drilling machine. The plates of the combing segments in combers are repaired by dressing and the needles are soldered. For this reason, enterprises in which such machines are available make use of a muffle electric furnace of laboratory type in the repair shop.

Spindle and flyer repair shop. Spinning and twisting spindles are the main parts of a spinning frame. Considering the high speed of spindle rotation which must be effected with great precision strict requirements are set towards the manufacture and restoration of spindle separate parts. Especially strict rules should be observed in the manufacture of the spindle blade, as its amplitude of oscillations must not exceed 0.15-0.3 mm depending on the whirl diameter. The thrust bearing and the spindle blade heel cone are subjected to heavy and rapid wear, while the seat under the roller bearings and

the exterior surface of the whirl experience much less wear. The wear of thrust bearing and heel cone as well as the residual flexure of the spindle increases the amplitude of spindle blade oscillations which results in an increase of the breakage rate. The main technological operations at the time of spindle repair are as follows: cleaning and degreasing; disassembly and sorting of defective parts; spindle blade straightening; eliminating the wear of the seating under the roller bearing and of the heel cone by grinding, electric spark building-up or chromium plating; restoring or replacing the thrust bearing; replacing the roller bearing; grinding the whirl surface; assembly and running-in of spindles.

At the time of repair of roving flyers the following operations are carried out: cleaning the slots and pipes from fluff and dirt; restoring the bushing, saddle, and reversing motion by clamping and building-up; dressing the feet and repairing the branches; checking the distance between the branches set apart, static and dynamic balancing of flyers.

Prior to the repairs, the spindles and flyers are cleaned and degreased in the washing department. The following equipment is provided in the workshop for spindle and flyer repair: tables for dismantling and sorting the units; a machine for straightening spindle blades, a machine for grinding the heels of spindle blades; a unit for electric spark hardening of parts; a machine for lapping and polishing spindle blade heel cones after electric spark building-up and for removing the burrs from the flyer branches; a device for pressing-out and -in thrust bearings; a device for flaring bushings in and out, and a stand for spindle running-in. A universal machine has been devised for flyers repair. Moreover, the shop has at its disposal a set of tools and instruments for sorting defective parts, an electric grinder and racks for storing units and parts.

The electric spark building-up of the heel cone surface is made with an electrode of hard alloy. Building-up is begun with three course layers and wound up with one or two finish coats. In this case, the thickness of the built-up layer is 0.2 mm which allows further machining to be made by lapping and polishing the heel cone.

Repair shop for fluted rollers, shafts and rods. The quality of produced goods and the machine efficiency greatly depend on the quality of repairs of fluted rollers in spinning, roving and drawing frames. Specifications allow the following run-out of fluted rollers: 0.15 mm for spinning and roving frames and 0.1 mm for drawing frames. The fluted rollers of cotton spinning frames are made of carburized steel or of surface hardened steel. The roller shafts of flax spinning frames are made of chromium plated steel and the fluted posts of stainless steel or chromium plated steel.

The main defects in the working rollers are: flexure, wear of necks and fluted surface, damaged threads and breakage of shanks.

Shaft corrosion in the fluted section is observed on the rollers of flax wet spinning frames. The restoration process depends on the kind of deterioration, but dressing is obligatory for almost all rollers. Worn necks are frequently restored and in flax spinning frames the post fluted surface is knurled.

In addition to fluted rollers different shafts and rods are restored in that workshop. As the fluted rollers and shafts are restored many operations require the use of the equipment installed in the fitter's workshops (for straightening, building-up and machining). For this reason, usually no separate workshop for roller repair is provided and the rollers are repaired in the fitter's shop. Disassembling, dressing and assembling of fluted rollers are most conveniently carried out on machines of a spectral design and the restoration of a fluted surface, by means of knurling devices. The restoration of the flutes on the heat-treated front drawing roller is possible after staff annealing, and in the event of inconsiderable wear—by chromium plating. The building-up of worn necks can efficiently be carried-out by using a welding unit mounted on the lathe slide.

Workshop for repairing small units of spinning frames. Such a shop or department is organized in big mills for more than 150 000 spindles. In workshops of this kind tension rollers, ring plates, lappets, cradles and separators are repaired.

Tension rollers are made of tin or carbolite. Tin rollers have a short useful life and their repair requires the use of special devices for unscrewing nuts, reaming of beads, dressing, elimination of indentations on the side face and rim. All these operations are carried-out on a universal stand. In carbolite tension rollers, the roller and shaft ball-bearings are worn-out, the rims are broken and contaminated, and the grease hardens. These rollers are inspected at the time of overhaul and medium repairs of the frame. The rollers are disassembled, washed in straw oil and packed with new grease and the worn-out bearings are replaced. For repairing such rollers the shop must have a mechanized washing unit and also hand presses for press-fitting and pressing-out ball bearings.

The ring plates are mainly repaired at the time of overhauls when rings, ring holders and antiballooners are replaced. The shop where the ring plates are repaired must be equipped with devices for rapid screws turning—in and out. Before removing spindle brackets or weighting arrangements from the spinning frame they must be cleaned from fluff and dirt, and if necessary the bearings must be replaced.

Roller covering shop. These workshops are intended for the repair of top or pressure rollers of spinning, drawing and roving frames and combers, as well as cleaning rollers and the drawing unit aprons. As rollers are repaired the following main operations are carried-out: cleaning and sorting; washing and wiping of bushings and shafts; checking the wear of rollers and selecting roller couples; stripping

and covering with new coatings; grinding of new coatings; cold and hot rolling-up of rollers; lubrication of spindles; cutting-off the felt from the clearers and glueing on a new felt, checking the rollers for hardness, cleanliness and machining precision; selection of the roller set in the frames.

The roller covering shop must be provided with the following equipment: a machine for stripping the elastic covering from the top pressure rollers of spinning and roving frames and fitting on new ones (production speed of 500 pcs/h); a device for stripping and fitting elastic coatings on top rollers with solid bushings (production capacity of 800-1200 pcs/h); a device for hot rolling of coverings in assembly with a metal bushing (production capacity of 300 pcs/h); a semiautomatic machine for sorting the coatings according to diameter in assembly with the bushing of top rollers of spinning and roving frames (production capacity of 900 pcs/h) and a semiautomatic machine with production capacity of 2000 pcs/h, a grinder with production of 150 pcs/h; a device for grinding the coatings of top rollers for spinning and roving frames in assembly with metal roller and spindle; a machine for coating, washing (production capacity of 1400 pcs/h); a device for fitting elastic coatings on drawing rollers (production capacity of 120 pcs/h; a device for cutting away the coatings from metal rollers of drawing frames and combers (production capacity of 300 pcs/h); a device for cutting the felt for clearers; a device for cleaning the clearers of roving and spinning frames; a device for applying glue on clearers; an instrument to check for run-out the top rollers and coatings in assembly with the bush in spinning, drawing and roving frames; a machine for hot calendering of the top roller coatings (production capacity of 800 pcs/h), etc. In addition to the main equipment there are also provided drying and exhaust cabinets, a bath, an electric stove for glue preparation, tables, racks for roller storage, and trucks for their transport.

Repair workshops for the spinning heads of the frame БД-200. The design of the open-end spinning frames БД-200 differs from that of ring spinning frames. The main working organ of these frames is the spinning head (centrifuge), which serves for the supply, opening and attenuation of the sliver and for the formation and reinforcement of the yarn by twisting. As the repair of the spinning heads directly on the frame is difficult, a high labour efficiency and good quality of repairs cannot be ensured.

The workshop for repairing the centrifuges of the БД-200 spinning frame is provided with the following equipment: stands for the pneumatic cleaning and balancing of the combing drum; a device for polishing the centrifuges and separators and also for rolling-up the centrifuges; tables for dismantling and assembling centrifuges and units; a table drilling machine; racks for storing reserve centrifuges and parts. All the assembly posts are provided with a set of

tools, gauges and devices. Cars accommodating 60-70 centrifuges are used for their transport to the working posts.

The frame БД-200 comprises also other units, the repair of which is more conveniently carried-out in repair workshops, as for instance, the reversing box, reducer, yarn guides, etc. At the time of repairs, these units are washed and ball bearings, glands, gaskets, gears and shafts are replaced. The free running bush and ball bearings of guiding pulleys are also replaced.

4. Weaving Equipment Repair Workshops

The structure of these workshops is almost the same as that of spinning equipment repair shops. The repair workshops in flax and silk weaving mills somewhat differ from those mentioned above as they have departments for the repair of Jacquard machines and of the winding heads of automatic weft winders.

General Purpose Repair Workshops

The main purpose of fitter's shops is the restoration of worn parts and the manufacture of single spare parts of simple design. The fitter's workshop comprises several departments: the machine department has one or three screw-cutting lathes, a milling cutter, a shaper, an upright drilling machine with a drilling diameter up to 35 mm; the fitter's department is equipped with a fitter's bench, table drilling and tool grinding machines, a hydraulic erection press for up to 100 kN, mechanical and hand lever shears or a metal sawing machine.

The welding compartment is equipped with a welding transformer or converter, a welder's table, a rough grinding machine with flexible shaft, a bench and a rack for storing parts, electrodes, tools and devices.

In the washing and defect detecting department, the same equipment is used as in the similar department of the spinning enterprise. The store of materials and the tool dispensing room are also organized in the identical manner.

Specialized Repair Workshops

In weaving enterprises special repair shops have been created for the labour-consuming restoration of separate most largely used units. In the case of shuttle looms the following units and parts should be repaired in specialized shops: the batteries, dobbies slays, crankshaft with bearings and carriers, the picking motion and reed; in pneumatic looms—the driving box; in rapier looms—the compressors, rapiers and shedding motion; in automatic weft winders—the yarn tension

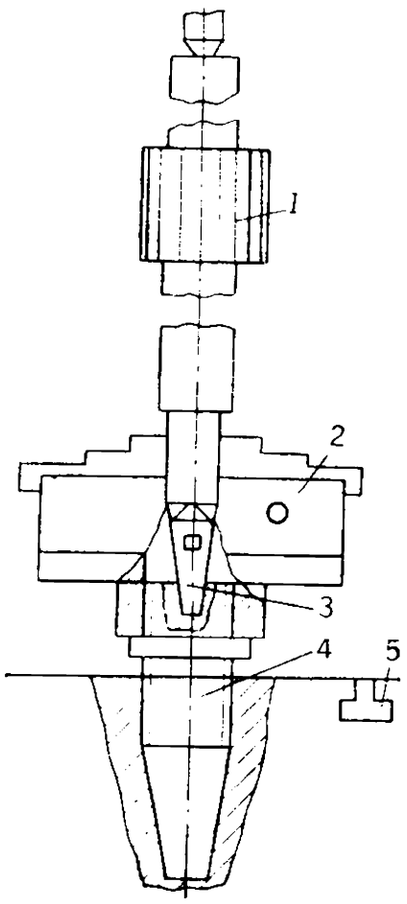

Fig. 156. Shaft splining device

devices and conveyors; and in sizing machines—the speed variators and reducers, etc. Most of these units are restored at the time of overhaul.

Loom units repair shop. In this shop the loom units are prepared and run-in. For restoring the shuttle loom units (type AT looms) stands are used for repairing and running-in the weft change motion, the dobby, the Jacquard machine and for the assembly and checking of the crankshaft with bearings. The box of the pneumatic loom (type P) is run-in on a stand of frame design. The compressor of pneumatic rapier looms (type АТПР) is repaired on a special control stand equipped with instruments for measuring the pressure of air supplied into the rapiers and for determining the temperature in the cylinder and piston rubbing zone. Rapiers are repaired on a stand, on which they are straightened and a plastic T-piece is fitted on the rapied rod.

Provided in addition to the stands are fitter's benches and table top drilling and tool grinding machines. Heavy units are placed on the stands by means of a hoist with a lifting capacity up to 0.5 t. Racks and cabinets are provided for storing small units, spare parts, tools and material. Hand and special cars are used for transporting the units. Moreover, different enterprises have designed devices and appliances for various kinds of repairs such as a device for cutting splined shafts for looms АТПР-100 on a gear milling cutter. With this aim, the device made as a three-cam chuck *2* (Fig. 156) with a centre *3* is fixed on the mandrel *4* screwed into the table of the gear milling cutter *5*. The cut splined shaft *1* is fixed in centres and its end is clamped in the chuck. This universal device may be used for cutting toothing of different diameter gears.

Shop for the repair of equipment on stands. Unlike the individual method of equipment repair, the repair of equipment on stands ensures a sharp reduction of equipment idle time, a considerable amelioration of working conditions at repairs, as well as the high quality of repairs and improved organization of work at the time of loom repairs.

When looms are repaired on stands, they are lifted and transported by a special bogie-crane above the equipment and further the loom is transported in the shop on a hand or electric car. The loom is lifted or lowered by a winch or a motor supplied with current from the line or accumulators arranged in the bogie. If the width of the passages is sufficient for driving-out the loom from the row, simple jack bogies are employed which are attached to the frames. The loom is lifted and transported either manually or by an electric car. The equipment is repaired on stands at the time of overhaul which is very time-consuming. The number of stand platforms must suit the number of spare looms.

In addition to the stands for loom repair, stands are also available for the repair and running-in of separate units. For carrying out small fitter's jobs there are provided table drilling and grinding machines, fitter's benches, electrified erection tools and devices, control tools and racks. The workshop comprises three departments, i.e. the washing department, the department for repair, running-in on stands and for painting, and the store for keeping the parts.

Slay and shuttle repair workshop. This shop is provided in all enterprises equipped with shuttle looms, and serves for carrying-out the repair of slay and shuttles and also for the manufacture and repair of different wooden parts. The workshop is equipped with a slotter, a scroll saw, a circular saw, a planer, a milling machine, an electric drill with a drill 23 mm in diameter, an electric glue boiler, a table drilling machine, an electric grinder, scales for shuttle weighing, a universal machine for shuttle repair, joiner's benches, and racks for storing slays and different materials.

Healds and reed repair workshop (pertains to the weaving mill only). It is equipped with a reed cleaning machine, a drop wire and heald cleaning machine, racks and tables for storing and repairing these units and parts. Frequently, reeds, healds and drop wires are cleaned and repaired in the premises of the drawing-in department of the mill.

5. Organization of Repair Working Posts

The proper organization of the working posts is one of the essential conditions ensuring high labour efficiency of repair workers and excellent repair quality. The *repair working post* is part of the workshop occupied by one worker or team, by the equipment and other means which the worker or a team is using for repairs. A properly arranged working post must be equipped with all necessary technical facilities conveniently disposed for carrying-out the given process. Repair workers have to operate either directly at the machine to be restored (disassembly or assembly of units and mechanisms), or on vices for mating the parts, carrying-out small repairs, etc.

When working at the machine, repair workers must have individual transportable cases with a set of necessary tools, gauges, small parts, wiping materials and others. A team must have at its disposal a bench with vices (it is advisable to have a movable bench).

A movable general purpose bench has been proposed for use by repair fitters. It is made as a cabinet of 1000 × 630 × 850 mm in size with special boxes and drawers for storing fitter's tools and spare parts. The upper part of the bench is made of boards 40 mm in thickness, covered with 1-2 mm thick sheet steel and edged with steel angles to ensure strength and rigidity. Under the upper part of the bench there are provided two top drawers, each divided in four or two sections for storing small parts and fixtures. At the sides, there are cabinets with collapsible doors for storing fitter's tools (files, drifts, cutting tools, etc.). Inside, the bench is divided by a shelf and wall in four sections. The top sections are intended for storing big tools (hammers, pullers, electric tools, and so on) and the bottom ones for storing big spare parts. At the front, the bench is closed with two doors. All the bench doors are made of 10 mm thick plywood and edged with a plank. To facilitate its displacement, the bench is mounted on a metal frame with four rubber-coated wheels. As an example, a list of tools, devices for repair teams and auxiliary materials is given below:

fitter's tools—fitter's hammers (220 and 500 g), copper hammers (500 and 1000 g), chisel, grooving chisel, bastard and smooth files of different sections, a sawing machine and blades, screwdrivers, a set of standard spanners and socket wrenches, a set of special wrenches (depending on the type and model of the machine), pliers, punches and different drifts, drills, centre punches, twist drills (in set), tap wrenches, threading dies and screw taps (set), tommy bars and marking tools;

control and measuring instruments—steel straight edges (from 100 to 1500 mm), a steel metre and measuring tape, level, plumb bob, thin cord (string), caliper, internal gauge, micrometer, watch indicator with stand, feelers, a thread gauge, angle gauge, standard square, a set of special gauges (depending on the type and model of the machine);

devices and auxiliary arrangements—standard and special pullers, jack, hooks, brushes, oilers and pans;

auxiliary materials—lubricating oil, chalk, emery paper, cup grease, rags, lining and wedges.

It is necessary to provide the working post with electric current supply and a socket to plug electric tools (electric drills, grinders, etc.).

6. Failure Prediction for Parts, Units and Mechanisms

Any assistant foreman knows that the preventive repair is a guarantee of trouble-free machine operation. Proper failure prediction is of great importance. There exist several methods of failure prediction, but they are all aimed at detecting the disarrangements in due time by their outward symptoms.

So for instance, let us discuss such a symptom as repeated breakages on the same spindle of a spinning frame. When using the existing method of yarn breakage determination in spinning frames, the repetition of yarn breakages on the same spindles is not registered and the causes of these breakages are not detected. However, this symptom means that some spindles do not properly operate. The existing methods of control must be replaced by control of each spindle at which the technical condition of spinning frames is simultaneously checked. When the breakage rate is irregularly distributed it may be considerably reduced, if in the course of checking first of all faulty spindles are located and the disarrangements are eliminated. For this in checking the Nos. of the spinning frame faulty spindles are registered indicating the date of checking and the No. of the side. These data are submitted to the foreman assistant servicing the frame who must take the necessary measures for eliminating the disarrangements in spindle operation.

The aforedescribed method should be used everywhere as the prediction of disarrangements and defects in parts, units and mechanisms allows their location and elimination in due time, thus ensuring much saving in time and finance.

REVIEW QUESTIONS

1. Discuss the kinds of repair used for textile machinery and give their characteristics.
2. What are the purpose and structure of central repair workshops?
3. What departments are general-purpose workshops of a spinning mill made up of? Give their characteristics.
4. What are the machines used in a workshop for the repair of card units? What kinds of repairs does it carry out?
5. How are the needles ground by electropolishing?
6. What kinds of repairs are carried out in a workshop for spindle and flyer repair?
7. How are top rollers and clearers repaired?
8. What is the purpose of specialized weaving equipment repair workshops?
9. How is the working post of repair workers organized?

APPENDIX

Medium Repair Sheet for Loom СТБ

No. of set	Number of loom	Assistant foreman	Department foreman	Loom condition

The loom has been delivered for repairs

Foreman _____

The loom has been accepted for repair

Foreman of repair workshop_____

Item No.	Name of operations	Remarks
	I. Loom framework	
1	Replace or repair frames, braces and brackets	
2	Replace bracket adjusting bolts	
3	Check warp beam rod bearings	
4	Check loom for horizontality	
5	Repair loom starting mechanism from the back-rest side	
	II. Loom drive	
1	Replace key bolt pulley	
2	Replace braking belt	
3	Replace copper-asbestos cover-plate	
4	Replace or repair braking pulley	
5	Replace or repair shafts, draw bars, plates and levers	
6	Replace or repair stop plate and locking finger	
7	Replace or repair clutch and plates	
8	Replace pins and shockle	
9	Check bearings	
10	Check roller interlock	
11	Adjust mechanism	
	III. Slay motion	
1	Replace teeth, clamping bolts and reeds	
2	Replace or repair slay swords	
3	Eliminate swing in the slay drive	
4	Eliminate slay beam displacement	
5	Check coaxiality of teeth from right and left-hand boxes	
	IV. Weft picking box	
1	Replace or repair screen, porcelain eyelets	
2	Eliminate swing of brake compensator rollers and replace bronze bushing	

Continued

Item No.	Name of operations	Remarks
3	Replace braking plate, porcelain eyelets	
4	Replace picking cam, bolts and cross shaft	
5	Check operation of the oil damper	
6	Replace picking stick and bolts for the shackle, ring and picker	
7	Replace picker guide	
8	Replace weft inserter guides	
9	Check torsion shaft in conformity with match marks "0"	
10	Eliminate swing of picking pipe	
11	Set clearance between picker and web inserter to 0.2-0.5 mm	
12	Set picking to 10+3 or 140+3°	
13	Check operation of atomizer	
14	Eliminate slotted cam displacement	
15	Eliminate swing of carrier, articulated member and slide block	
16	Replace scissors, centring flap and scissors shaft	
17	Replace or eliminate three-toothed cam swing	
18	Replace weft feeler	
19	Eliminate three-armed levers swing	
20	Eliminate swing of levers and draw bars of receiver, weft inserter openers, and weft feeder	
21	Replace receiver, weft inserter opener and feeder	
22	Eliminate oil leakage	
23	Eliminate belated retreat of weft feeder	
24	Adjust all mechanisms	
	V. Pick finding motion	
1	Check and reassemble chain	
2	Eliminate vertical roller jamming	
3	Check intermediate gear and gear on take-up roller	
4	Replace limiting finger and screws	
5	Adjust spacing plate operation	
6	Adjust mechanism with setting of all allowable clearances	
	VI. Colour change mechanism	
1	Check and reassemble chain	
2	Check and reassemble card	
3	Eliminate clearances between gears	
4	Replace pressure roller, shaft and fork	
5	Repair weft feeders	
6	Replace weft feeder guides	
7	Replace coupled cam	
8	Eliminate swing of the locator lever and of all drawbars	
9	Eliminate swing of the crank and drawbar slider	
10	Check bearings	
11	Adjust mechanism	
12	Replace roller and eccentric finger	

Continued

Item No.	Name of operations	Remarks
	VII. Receiving box	
1	Replace side walls and guiding plates made of textile based laminate	
2	Replace brake heads	
3	Replace feeler and pawl	
4	Replace or repair locator	
5	Eliminate carrier and slotted cam swing	
6	Replace opener, screws and ejector	
7	Replace or repair locator	
8	Eliminate swing of locator roller and latch shaft	
9	Replace latch adjustment screw	
10	Eliminate swing of all drawbars, three-armed levers and sliders	
11	Repair controller roller, clutches and rollers	
12	Adjust weft inserter entry into box (early, medium and late)	
13	Eliminate oil leakage	
14	Adjust all mechanisms	
	VIII. Conveyor	
1	Check and reassemble chain	
2	Check bearings	
3	Coordinate conveyor operation with weft inserter receiver	
4	Replace or repair conveyor brushes	
	IX. Shedding motion	
1	Replace tappets, levers, rollers and drawbars]	
2	Eliminate swing in all articulated joints	
3	Replace shackle, bronze axles	
4	Replace broken drawbar guides	
5	Inspect all bearings	
6	Check and reassemble chain	
7	Replace heald plates	
8	Adjust shedding motion for easy disengagement	
9	Replace tension sprockets and sprocket axles	
10	Eliminate oil leakage	
	X. Warp delivery motion	
1	Replace or repair driving disk with boss	
2	Replace friction rings and gaskets	
3	Eliminate clearances in all axes of rotation	
4	Examine all bearings	
5	Check satellite gears for easy rotation	
6	Proceed to proper installation of warp delivery motion	
7	Replace or repair toothed levers and eliminate oil leakage	

Continued

Item No.	Name of operations	Remarks
	XI. Cloth take-up motion	
1	Eliminate roller swing	
2	Eliminate swing of take-up roller and pressure roller	
3	Replace felt on pressure roller	
4	Obtain proper meshing of gears	
5	Eliminate pawl swing	
6	Check friction clutch, sprocket chain, cloth rollers, pressure levers and change gears	
	XII. Selvedge binder mechanism (left-hand, middle and right-hand)	
1	Eliminate swing of clamp and hook	
2	Eliminate delamination of clamp from the reed	
3	Replace clamp, hook, scissors, flaps	
4	Replace or repair brackets for harness guides rod	
	XIII. Warp stop motion	
1	Replace roller, cam, fork and plate	
	XIV. Temples	
1	Replace ring, cover, bracket, nut and roller	
	XV. Oil line	
1	Check operation of oil line	

XVI. Replace all faulty screws, detected during disassembly

Notes. 1. The assessment mark "Excellent" is awarded when the production capacity and the grade are not inferior to those planned and in the absence of gross defects capable of causing the premature wear or breakage of parts.

2. The condition of the loom delivered for repairs is evaluated by the foreman of the repair work shop together with the technical attendant taking into consideration loom operation till the time of its stoppage and the condition of mechanisms and separate parts depending on the maintenance during servicing.

3. The assessment of the loom after repairs must be recorded in the repair order and in the repair sheet.

The loom has been delivered from repairs by the foreman of the repair workshop _____

The loom has been accepted from repairs with the assessment mark _____

Senior foreman for equipment _____

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